US Army Corps of Engineers ®

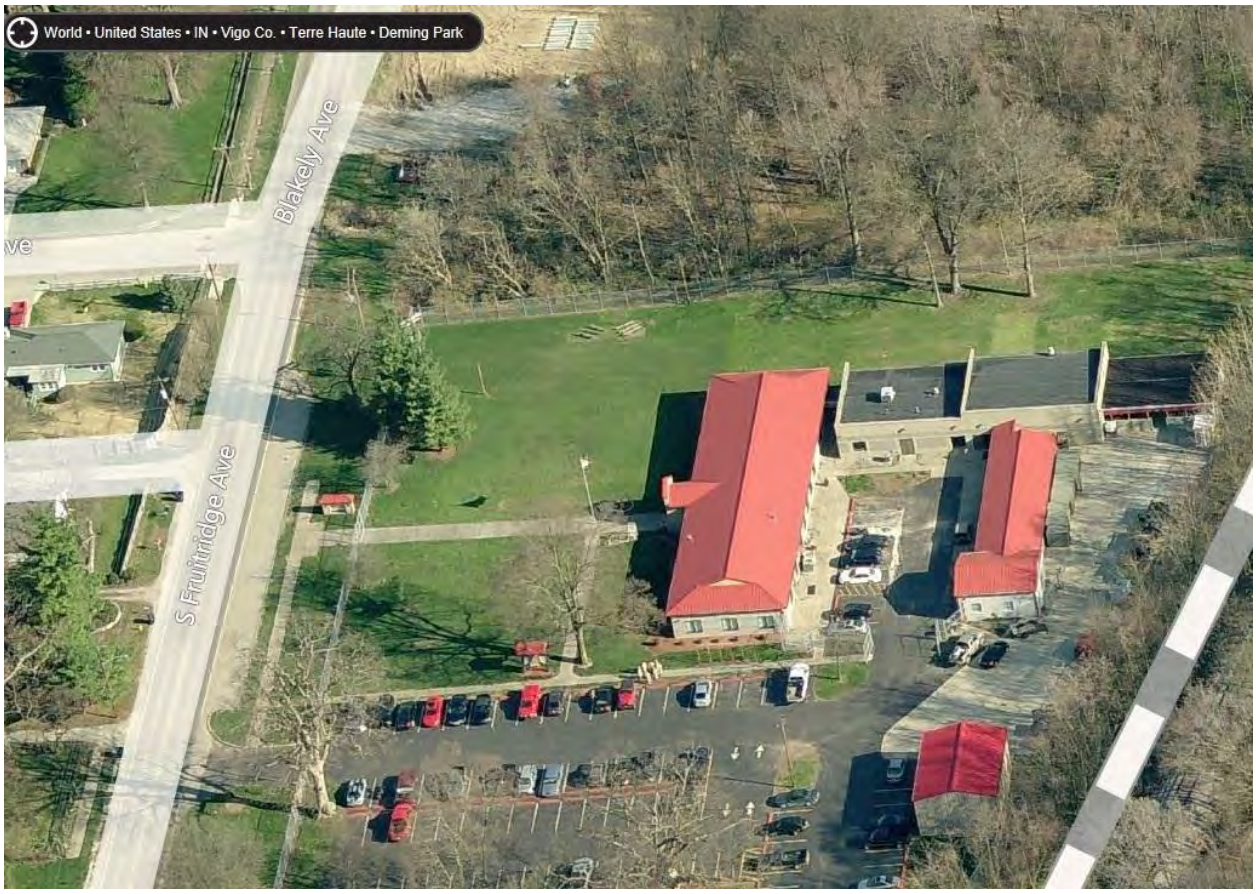
Design Analysis – Final, For Construction

Solar Photo Voltaic (PV) Systems

in Support of Marine Force Reserves (MFR) Sites

Project Number: 541320
Terre Haute, Indiana

August 2014



BLAIRREMY ARCHITECTS

7 Mickey Mantle Drive
JDM Place, Suite 350
Oklahoma City, OK 73104

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Chapter – I General

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Chapter I General

Design Analysis
Solar Photo-Voltaic (PV) Systems
in Support of Marine Force Reserves (MARFORRES)
Terre Haute, Indiana

1. General Description:

The Marine Forces Reserve Facility will receive photo-voltaic panels on approximately 8,140 SF of the existing roof. During the time of the site visit, the roofs appeared to be in good condition. Therefore, repairs to the high sloped roofs with standing seam metal roofing, and low sloped roofs with a roofing membrane material are not recommended.

2. Design Analysis Sections

This Design Analysis reflects Blair Remy's interpretation of criteria contained in the Statement of Work for A-E Services for Photo-Voltaic System Designs at the Marine Forces Reserve (MARFORRES) located in Terre Haute, Indiana.

Included in this document are discipline narratives addressing:

- Structural Engineering
- Architectural
- Electrical Engineering

3. Project Schedule:

Following is the projected project schedule:

- 30 May 2014 – 35% Design, Analysis Specifications for Govt. Review
- 8 August 2014 - 95% Design, Analysis Specifications for Govt. Review
- 15 August 2014 - Final Package

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Chapter – VII Architectural

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Chapter VII Architectural

Design Analysis
Solar Photo-Voltaic (PV) Systems
in Support of Marine Force Reserves (MARFORRES)
Terre Haute, Indiana

1. Design References:

a. International Building Code – 2012 Edition

b. NFPA 101, Life Safety Code – 2010 Edition

c. NFPA 220, Standard on Types of Building Construction – 2009 Edition

d. TI-800-01, Design Criteria

e. MIL-HDBK-1190, Facility Design Manual

f. UFC 3-110, Design: Architecture

g. AFI 32-1084, Standard Facilities Requirements Handbook

h. ABA, Architectural Barriers Act

i. OSHA, Occupational Safety and Health Administration Guidelines

2. General Descriptions of the Project:

The project is to install a Solar Photo-Voltaic (PV) System on several buildings at the existing facility. The intent of this action is to fulfill the requirements of the National Defense Authorization Act of 2007 and Executive Order 13423 regarding renewable energy requirements (25% renewable by 2025).

3. Basis of Design Summary:

The Photo-Voltaic System will be designed with evaluations of the site, needs of the user, and budget limitations. The project is an installation of an 80 kW photovoltaic system. A suitable location for the PV array will be determined by shading patterns and building orientation. See drawings for locations of photovoltaic panels, and the Alternate Bid Item for ground mounted covered parking. PV panels installed on standing seam metal or metal panel roofs will have a clamp mounting method. PV panels installed on low sloped roofs will be attached to a non-roof penetrating molded polyethylene base. The layout of PV panels will be designed around obstructions such as antennas, plumbing and mechanical vents. The A/E team recommends trimming trees on the Southwest corners of the facility, in order to reduce shading on the PV panels.

Fall Protection during installation shall be a part of the means and methods of construction and fall under the responsibility of the contractor. A permanent Fall Protection system is beyond the Scope of the project. However, the A/E team recommends Fall Protection during the

maintenance of the photovoltaic system throughout its life cycle. In order to avoid direct attachment to the structural systems, and penetrating the existing roofing material, we suggest the following. For low sloped roofs consider a non-penetrating anchor such as the Freestanding Counterweight Anchor from Capital Safety, Brand: DBI-SALA, Model: 7255000. For high sloped roofs consider the Miller Fusion Roof Anchor, Model: SKU X10001 or Model: SKU X10011. See Appendix – F Fall Protection, for more information.

The A/E team recommends placing photovoltaic panels on the existing roof structures. The structure will be reinforced or braced if the additional loads caused by the PV panels require it. See the structural design analysis for possible roof structure access locations, and/or suggestions for reinforcing structural members.

The oldest portion of the facility, was originally constructed with a low sloped roof. However, a high sloped roof was added later during a renovation. Visual access to the roof's structure is through the interior attic access ladder, in this area. All light fixtures and HVAC components directly under the structure to be reinforced, will be supported, secured, or removed. The contractor will store and replace building components as required to perform the work.

Chapter – VIII Structural

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Chapter VIII Structural
Solar Photo Voltaic (PV) Systems
In Support of Marine Force Reserves (MARFORRES) Sites
Terre Haute, IN

1. Design References:

a. 2012 International Building Code

b. ACI 318-11, Building Code Requirements for Reinforced Concrete

c. AISC Manual of Steel Construction, Load and Resistance Factor Design, 14th Edition

d. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures

e. ACI 530.1-08, Building Code Requirements for Masonry Structures

f. SDI Pub No 29, Steel Deck Institute Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Metal Floor Deck With Electrical Distribution

g. UFC 1-200-01 (1 July 2013), Unified Facilities Criteria, Design: General Building Requirements

h. UFC 3-301-01 (1 June 2013), Unified Facilities Criteria, Design: Structural Engineering

i. UFC 4-010-01 (9 February 2012 including change 1, 1 October, 2013), Unified Facilities Criteria, DoD Minimum Antiterrorism Standards for Buildings

j. UFC 4-023-03 (14 July 2009), Unified Facilities Criteria, Design of Buildings to Resist Progressive Collapse

2. General Description:

The site PV installation involves installing a PV panel system and associated hardware to three Reserve Center buildings at the S. Fruitridge Avenue, MARFORRES site in Terre Haute, Indiana. This requires the evaluation of the existing roof framing system, and determination of its adequacy as load-supporting systems under the new dead and wind loads associated with the PV systems. The original Reserve Center buildings, 1650 s.f. were constructed in 1952 and expanded with an addition in 1980's. The roofs are sloped 4V: 12H except for the connector addition which is flat. Roof joists of the sloped roof are open-web wood trusses spaced 2'-0" c/c bearing on wood stud knee walls that are supported by cmu walls and are constructed over an original flat concrete roof slab. The addition that was done in the 1980's is constructed of steel bar joists and bearing on cmu walls. Split-face cmu provides shear-panel lateral stability around the perimeter. Since the roof truss bearing is on knee-wall type stud framing as much as 30 in. above top of cmu, additional lateral restraint will need to be added to stiffen the load path to the cmu shear walls.

Lateral Stability

The PV system placement on sloped roofs will create an increased lateral force on the existing lateral force-resisting system. Additional struts will be added to provide a stiffened load path to the cmu shear walls. The

PV system will not exceed original vertical design of 20 psf live load. Equipment load (4 psf) will supersede the inclusion of live load (20 psf) in considering critical loading combinations with PV panel loads.

3. Progressive Collapse

Progressive collapse is a consideration in cases where a structure requiring progressive collapse analysis for its original design is now loaded with new dead loads at the roof, which increase the loads on redundant members using the alternate path and/or tie force methods.

4. Foundations

Existing foundations are less of a concern than the smaller framing at the roof. Typically, foundations will have some excess capacity, and the load increase due to the panels will be modest.

5. Design Loads

a. Roof Live Load	20 psf where no PV panels
	PV Panels and Hardware: 4 psf
b. Floor Live Loads	N/A
c. Wind Load	115 mph (Risk Cat. II)
d. Seismic	S_S = 0.33g; S_1 = 0.1135g
e. Snow	20 psf Ground Snow Load

6. Materials

a. Concrete, typical	N/A
b. Reinforcing Steel	N/A
c. Mortar	N/A
d. Cold Formed Steel	N/A
e. Structural Steel	N/A
f. Aluminum	ASTM 6061-T6
g. Wood	Southern Yellow Pine, #2

7. Specifications

Refer to Specifications

8. Calculations

See Appendix C – Structural Calculations

Chapter – X Electrical

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Chapter X Electrical
Solar Photo Voltaic (PV) Systems
In Support of Marine Force Reserves (MARFORRES) Sites
Terre Haute, IN

1. Design References:

   The most recent edition of referenced publications applies unless otherwise specified:

   a. IEEE 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems,

   b. NFPA 70, National Electrical Code

   c. UFC 3-501-01 Electrical Engineering

   d. UFC 3-520-01 Interior Electrical Systems

   e. Energy Policy Act of 2005 (EPACT 2005)

2. General Description:

   The site PV installation involves installing a 80KW DC Rated PV system, which will involve installing PV Modules on existing pitched roofs and flat roofs as well as one side of a pitched roof. The power generated from these modules will then be distributed back into the buildings electrical system at the main distribution panel located in the main electrical/mechanical room. AT present time the design includes 285, 275W DC rated modules for a combined output total of 78.3KW.

3. Exterior Electrical Distribution:

   The existing exterior medium voltage electrical distribution will not be reworked for this project.

4. Facility Electrical Power System:

   The facilities power distribution system is divided into the following systems:

   a. Normal Power Distribution:

   The existing power system will be modified for this project. New PV combiner circuit breaker panels are provided along with a main distribution circuit breaker panel as well as PV Modules, micro inverters, and racking for this project. The main tie in for the PV system with the existing system will be at the Main Disconnect for the building on the line side.

   b. Emergency Life Safety Power Distribution

   Not applicable for this project

   c. Emergency Power Distribution

   Not applicable for this project

   d. Critical Power Distribution

   Not applicable for this project

5. Interior Lighting:

   Not applicable for this project

6. Lightning Protection System (LPS):

a. A lightning protection system risk assessment was completed and it stated that a lightning protection system should be installed. The Design for the PV system design currently does not show lightning protection system.

7. Energy and Management Control System:

   The existing EMCS system will not be modified for this project.

8. Intended User Responsibility for O&M:

   a. Not applicable for this project.

9. Service Responsibility:

   a. Exterior medium voltage electrical distribution: Not applicable at this time

   b. Interior electrical distribution: Interior facilities provided include the solar panels and racking, main PV combiner panels, PV distribution panel, and dry type transformer.

10. Design Provisions for O&M Enhancement and Cost Reduction:

   a. Access: Code recommended working space for maintenance is provided for all electrical equipment installed.

11. Basic Materials of Construction:

   a. All conductors are copper with THHN/THWN-2, 90 degrees C rated insulation. Minimum size #10.

   b. All conduit is EMT. Minimum conduit size is 3/4-inch.

   c. All exterior electrical equipment is NEMA 3R construction. Except boxes on the roof will be rated NEMA 4X minimum.

   d. All electrical equipment and panelboards utilize copper buses. All circuit breaker sizes less than 400 amperes are 80% rated and all sizes 400 amperes and larger are 100% rated and equipped with solid state trip devices.

   e. Communications cabling comprises plenum rated cables. All data and telephone cabling is Cat-6 solid copper.

   f. Electrical equipment and materials are generically specified using functional or descriptive specifications to avoid using “Brand” or “Manufacturer’s” names unless an “approved equal” designation is included to indicate quality and performance requirements where a “Brand” or “Manufacturer” is used as a Basis of Design.

12. Specifications:

Refer to Specifications List

13.Calculations:

Refer to Electrical Appendix.

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Appendix – A PV System Site Survey Info Report

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Photo-Voltaic (PV) Systems

MARFORRES

Terre Haute, Indiana

Prepared for:

US Army Corps of Engineers
Fort Worth District

Prepared by:

BLAIRREMY ARCHITECTS

7 Mickey Mantle Drive
JDM Place, Suite 350
Oklahoma City, OK 73104

MERRICK® & COMPANY

3575 Koger Blvd., Suite 235
Duluth, GA 30096

MARCH 2014

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1. EXECUTIVE SUMMARY

The Corps of Engineers (Fort Worth District) has retained A/E Services from Blair Remy Corporation for Solar Photo Voltaic (PV) Systems design for the MARFORRES Site in Terre Haute, IN. The PV System project includes the design of an 82 kW Solar PV System installation on existing facilities at the site in support of fulfilling the requirements of the National Defense Authorization Act of 2007 and Executive Order 13423 regarding renewable energy requirements (25% renewable by 2025).

2. PROJECT LOCATION AND FIELD VISIT SCHEDULE

2.1. Project Location

Marine Force Reserves site at Terre Haute, IN.

2.2. Field Visit Schedule

The site visit for field survey was conducted on 25 March 2014.

3. FIELD VISIT NOTES

3.1. Field Visit Attendee List

NAME	PHONE	EMAIL
Bernard Braddick	(405) 340-9503	bbraddick@blairremy.com
Judd Oakes	(678) 281-0907	Judd.Oakes@merrick.com

3.2. General Meeting Notes

The PV systems site visit was conducted during typical business hours on Tuesday 25 March 2014. Weather conditions were cold, approximately 30-35 degrees. Survey was delayed due to morning snow fall. Around 9:30 am the snow stopped, allowing for exterior observations. It was overcast until around noon.

The A/E Survey Team was comprised of Bernard Braddick with Blair Remy Corp. and Judd Oakes with Merrick, the architectural and electrical engineering representatives, respectively.

The A/E Survey Team was able to enter all spaces considered for PV panel installation. The VMF (vehicle maintenance facility) was viewed from the ground. While on site the A/E team requested as-built and shop drawings for the existing structural systems, and received the Reserve Center Facility Addition 1 (flat-roof) as-builts. Photos were taken of the documents the morning of the site visit.

The Vehicle Maintenance building is not considered for PV panels because of its orientation and location among large trees.

4. CIVIL/SITE OBSERVATIONS

4.1. General Observations

The site is located in a heavily wooded, residential area. Roofs are a mixture of high and low slopes. The high sloped roofs of the Original Reserve Center and Reserve Center Addition 2 have a standing seam metal finish, at a 4/12 pitch. The low sloped roof of Reserve Center Addition 1 is sloped approximately a half inch per foot, facing north. The ballasted mounting system for the PV panels on the low sloped roofs must account for the roof sloping in the wrong direction. Unfortunately, the majority of the roof areas that could be used for PV panel installation, are not ideally oriented. If allowed by the government, placing ground mounted/ covered parking would be a feasible option from a PV panel efficiency standpoint.

Railroad tracks run along the east of the base. Tall trees affect photovoltaic panel design and layout. There is a large deciduous tree just to the southwest of the Original Reserve Center that affects PV placement on the southwest side of the roof. If the tree is removed or trimmed, it could allow the placement of additional panels on that portion of the roof.

It is ideal to install fixed photovoltaic panels facing south in open locations that are not obstructed from the east or west.

Possible laydown areas observed during the site visit include (1) the full east side and the north west portion of the Original Reserve Center, (2) the low sloped roofs of the Reserve Center Addition 1, and the east side of the Reserve Center Addition 2. The central parking lot to the south of the Original Reserve Center has an ideal orientation for photovoltaic panels if additional capacity is needed.

All buildings surveyed were single story. Contractor access shall be coordinated with the base.

4.2. Site Access and Layout

The A/E team entered the secured gate on South Fruitridge Avenue. It provides the only access to the site. See Site Aerial Photo below.

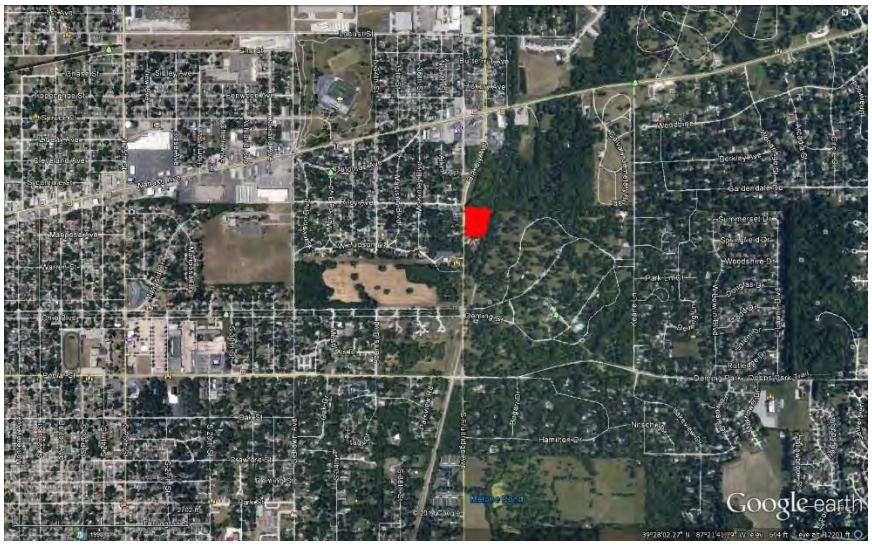

Figure 1 – Site Location Photo

Figure 2 – Labeled Aerial Image

4.3. **Site Constraints**

There is one entrance/exit gate, and three parking areas. The northern parking area is the smallest and is centered between the building wings. It is used primarily for personnel parking. The south parking area is surrounded by large trees which prevents it from being a viable area for the PV panels. The central parking area is the largest of the three and appears to be a good candidate for a ground mounted/covered parking PV system as it is least affected by the surrounding trees.

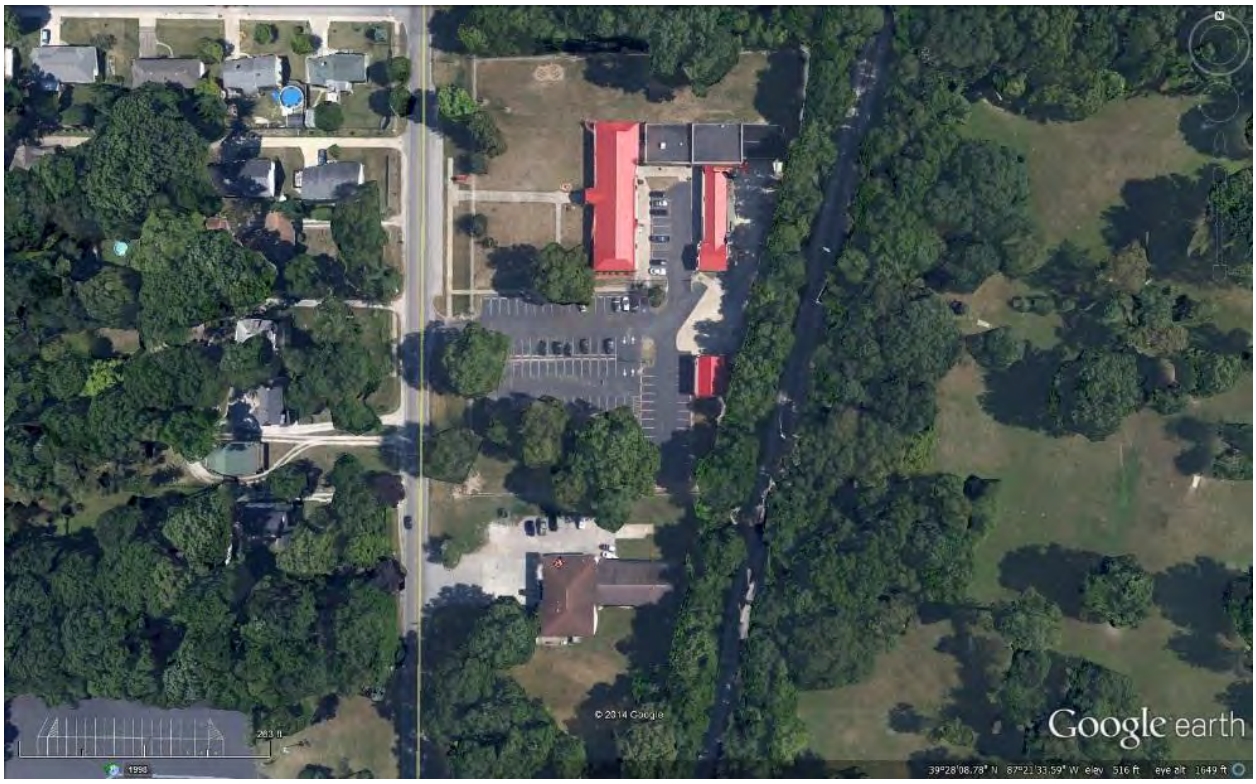

Figure 3 – Google Image of the Site

5. **ARCHITECTURAL OBSERVATIONS**

5.1. **General Observations**

In general, building exterior finishes and materials appear to be in good condition. The standing seam metal roofs of the Original Reserve Center and Reserve Center Addition 2 are in good condition. There aren't many roof penetrations caused by plumbing or mechanical vents. The low sloped roof of Reserve Center Addition 1 also appears to be in good condition; however, HVAC equipment, plumbing and mechanical vents are located on the roof. Equipment and components on roofs act as an obstruction to photovoltaic panels.

5.2. Roof Observations (Architectural)

All high sloped roofs have a standing seam metal finish, at a 4/12 pitch. The A/E team did not find any evidence of roof ponding on low sloped roofs where photovoltaic panels are planned. At the time of the site visit, the A/E team did not discover any visible leaks on any of the roofs.

Figure 4 - Roof Photos

Original Reserve Center: The Original Reserve Center as built with a flat roof; however, during a renovation, a pitch roof was built over the existing roof.

Reserve Center Addition 1: This addition was built with a flat roof.

See photos below, two of the Original Reserve Center and one of the Reserve Center Addition 1, respectively.

Figure 5 – Existing Structural Conditions

5.3. Limited Floor Plan Observation

The Original Reserve Center appears to have been built in the 1950s and serves as the main entry for personnel and visitors. It appears to be the oldest building on the site, with additions being made over the years. The original building had a flat roof which was changed to sloped during a previous renovation. Evidence of this can be seen from the attic which is accessible

from pull down ladders located in the corridors. HVAC equipment is located in this attic. The flat roofs of Reserve Center Addition 1 can only be accessed via ladders from the exterior.

6. ELECTRICAL OBSERVATIONS

6.1. General Observations

The Main Reserve Center has an existing 800A, 3-phase, 208Y/120V service feeding the building. The secondary is run under ground to a CT cabinet than inside the building to an 800A Disconnect than from this disconnect distributed to an 800A 3-phase Panel Board

6.2. Roof Observations (Electrical)

The roof where PV panels will be located along the west and east sides of the main reserve center are mainly free of any obstructions such as mechanical units there are a couple of vent stacks that will have to be worked around but these are minimal. The flat roofs on the north side of the building have mechanical units and vent stacks that will have to be worked around but does not overall impact the module area. A lightning protection system is not currently installed on the building and this will need to be provided to protect the PV panels.

6.3. Electrical Room

The building does not currently have a dedicated electrical room. The disconnect and main panel are located in rooms that have other uses.

Figure 6 – Existing Main Disconnect and Panelboard

6.4. Limitations

Many buildings on site do not have roof access. All of the visual roof observations were completed on the ground or with a ladder provided by the A/E team.

7. STRUCTURAL OBSERVATIONS

Structural information will be forthcoming and under delivered under separate cover.

8. CHALLENGES

8.1. Architectural Challenges

None.

8.2. Electrical Challenges

The installations of PV systems for the buildings will be fairly straight forward electrically but some challenges may come as far as communications requirements for the PV meter and site specific utility metering requirements.

9. RECOMMENDATIONS

9.1. General Recommendations

A/E recommends placing PV panels on the full east and north west portion of the Original Reserve Center, on the flat roof of the Reserve Center Addition 1, and on the west side of Reserve Center Addition 2. The PV panels can be installed on the existing roof structure, structure to be reinforced or braced if required.

Figure 7 – PV Layout Site Plan

Although beyond the project's Scope, the A/E suggest Fall Protection during maintenance of the photovoltaic system. For low sloped "flat" roofs, A/E suggest a non-penetrating Freestanding Anchor Tie-Off system. For high sloped standing seam metal roofs, A/E suggest a non-penetrating Clamped Anchor Tie-Off system. The Government should consider the systems below or similar systems that would not require penetrating the roofing membrane/material and causing a potential leak.

FREESTANDING COUNTERWEIGHT ANCHOR

Freestanding Anchor Does Not Require Attachment to Working Surface and Provides a Safe and Versatile Fall Arrest Rated Tie-Off Point!

- Non-penetrating design does not attach to the working surface, reducing the possibility of damage
- Built-in shock absorbing post provides added safety to user and structure
- Fall arrest and restraint rated for one worker for jobsite versatility
- For use in general concrete, steel or asphalt construction
- Approved for use on these roof types: concrete, single ply membrane, bitumen membrane, asphalt sanded and asphalt stone chippings
- Ideal for use on flat surfaces up to a maximum of 5 degrees slope/pitch
- Counterweights are 45 lbs. (20.3kg) and come with a integral carrying handle for easy transport and set-up

FREESTANDING COUNTERWEIGHT ANCHOR

Safe and Secure Anchor The freestanding counterweight anchor provides a tie-off point for personnel performing work on flat roofs or structures. The anchor is fall arrest rated and can be used as a single anchor point system. After set-up, simply attach your shock absorbing lanyard, self retracting lifeline or rope grab and lifeline and you are ready to go.

Non-Penetrating Design This anchor is a counterweight type, simply placed on top of the working surface. Weighted bases are added to rubber trays that are connected to a shock absorbing tie-off post. The anchor's freestanding design installs without penetrating the roof sheathing or surface, saving valuable time and money. In addition, the design reduces the possibility of surface damage, roof leaks and voided roof warranties.

Specialized Load Distributing Design This anchor incorporates a revolutionary shock absorbing system called LEAP™. The LEAP™ post (with tie-off point) has an integral energy absorber that deploys in a controlled manner to absorb the forces generated during a fall. This specialized design provides added safety to the attached worker and better distributes the forces to the anchor and structure. By limiting the forces this way, the integrity of the roof is also preserved.

Easy Installation Installation of the anchor system is simple, fast and efficient. Due to its modular design, the installer will never have to lift more than 45 lbs. (20.3kg). In some applications, the entire system can be lifted (by forklift or crane) into place for instant set-up and use. Refer to instruction manual for complete details.

Counterweight Anchor Models:

7255000: Freestanding Counterweight Anchor, includes sixteen 45 lb. (20.3kg) plates, roof post, base and D-ring

7200439: Single Counterweight Only, 45 lbs. (20.3kg)

Step 1

Align rubber trays into square pattern using notches

Step 2

Install the "L" bolts into the slots on the rubber trays

Step 3

Stack plates (weights) over bolts and onto rubber trays

Step 4

Set post and base onto the "L" bolts and plates

Step 5

Install the remaining four plates and tighten bolts/nuts

Specifications:

Counterweight Plates: Cast iron, galvanized ***Rubber Trays:*** Carbon steel, PVC coating ***"L" Bolts:*** Carbon steel, galvanized
Roof Post and Base: Post is painted stainless steel, the base is painted carbon steel ***D-ring:*** Forged steel, zinc plated
Standards: Meets EN 795:1997 Class E requirements.

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USA: 800.328.6146 • Canada: 800.387.7484 • Asia: +65 6558 7758 • Australia: 1800 245 002 • New Zealand: 0800 212 505
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New!

MILLER Fusion™

Roof Anchor Post

Permanent or Temporary Solution for Roof Safety

- Versatile single-point anchor adapts to a wide range of roof designs
- Attachment to the roof surface is quick and easy reducing installation time by more than 50%
- Protects the worker by maintaining a secure connection to the structure in the event of a fall
- Protects the structure during a fall with a unique energy-absorbing load distribution system

INNOVATIVE ENERGY-ABSORBING DESIGN

MILLER® by SPERIAN

New!

MILLER Fusion™ Roof Anchor Post

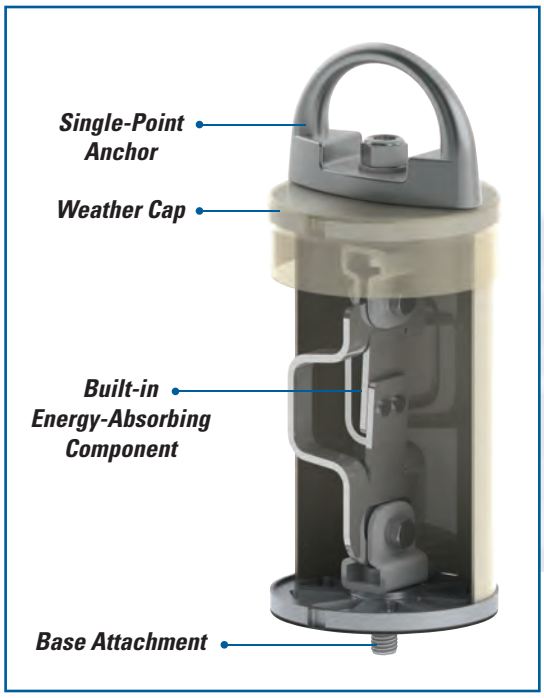
*The new versatile, single-point **Miller Fusion Roof Anchor Post** adapts to a wide range of roof designs with its innovative base plate engineered for temporary or permanent installation to the roof surface.*

When properly installed, a dependable fall protection connection is established. Should a fall occur, forces are reduced with its energy-absorbing design to maintain a secure connection to the structure.

*The easy-to-install **Miller Fusion Roof Anchor Post** is designed for quick set-up and does not require roof penetration to sub-surface rafters or trusses.*

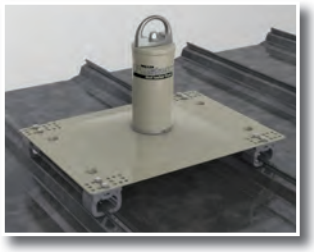
- **Versatile single-point anchor adapts to a variety of roof designs** – With a variety of models available, the Miller Fusion Roof Anchor Post can accommodate most industrial roof designs including standing seam, membrane, built-up, metal sheathing, concrete and wood.
- **Attaches to the surface of existing roof structures** – Quick, easy installation reduces cost requiring minimal labor and eliminating the need for roof penetration and repair.
- **Significantly reduces the fall forces on the roof structure** – In the event of a fall, the top of the Miller Fusion Roof Anchor Post reorients with the force in a direct line and activates the patent-pending energy absorber.
- **Durable design that withstands the changing outdoor environment** – Internal components are constructed of stainless steel. The steel post and base are plated with zinc followed by a premium powder coating for two layers of protection.
- Models for steel decking, concrete and wood can be used on other non-roof structures.

Modular bar extenders accommodate additional standing seam widths.



In the event of a fall, the Miller Fusion Roof Anchor Post orients in the direction of the force, the built-in, energy-absorbing component activates and the base remains securely attached to the roof surface.

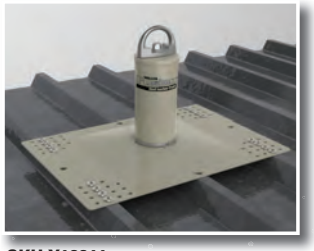
Miller Fusion Roof Anchor Post adapts to a variety of roof structures



SKU X10001

Standing Seam Design

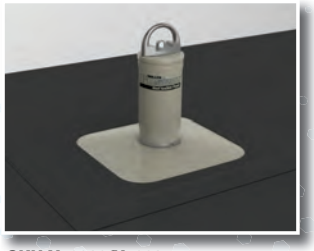
- Aluminum clamping mechanism is designed to pre-install to the base plate and is self centering for easy installation.
- The clamping bolts are tightened from above the plate for easy fastening and inspection.
- Can be used for permanent and temporary installations.
- Three models are available to accommodate standing seam spacing up to 24-inches *(610 mm)*.*



SKU X10011

Metal Sheathing Design

- Designed to attach to metal sheathing with a minimum 24 gauge *(0.024-inch [.61 mm])* thickness.
- Hardware kit includes sealing materials to prevent water damage to roof.



SKU X10030/X10031

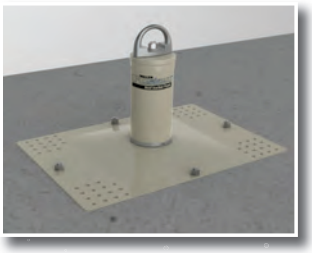
Membrane/Built-up Design

- Easy-to-install toggle kit fastens through membrane, insulation and into metal sheathing, wood sheathing or concrete.
- Models available for built-up roof thicknesses accommodate up to 10.5 inches *(267 mm)*.

SKU X10040

Wood Design

- Includes lag screw kit.
- Installs into plywood with minimum thickness of 5/8-inch *(15.9 mm)* CDX.
- *Designed for temporary installation only.*



SKU X10050

Concrete Decking Design

- Includes concrete expansion anchor kit.
- Installs into concrete decking with minimum thickness of 6.5 inches *(165 mm)* and minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*.

SKU X10020

Multi-Purpose Metal Sheathing, Wood and Concrete Design

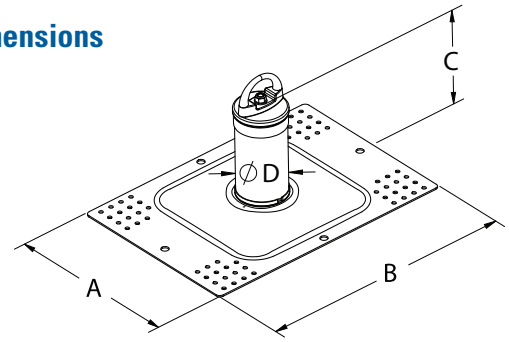
- This multi-purpose post uses the same base as models X10011, X10040 and X10050.
- Miller specified hardware must be purchased for this base. *(This model does not include hardware.)*

Applications

- *Roof inspection and maintenance*
- *Air conditioning, ventilation fan and solar panel maintenance*
- *Skylight cleaning*
- *Debris removal from gutters*
- *Installation and maintenance of satellite dishes and other communication systems*

**Complete list of models (SKUs) on back page.*

Dimensions



SKU	WIDTH A	LENGTH B	HEIGHT C	POST DIA. D
X10000 X10010	15.25 in. *(387 mm)*	18.0 in. *(457 mm)*	8.6 in. *(218 mm)*	4.0 in. *(102 mm)*
X10001 X10011 X10020 X10040 X10050		22.0 in. *(559 mm)*		
X10030 X10031			9.0 in. *(229 mm)*	
X10002	15.6 in. *(396 mm)*	26.0 in. *(660 mm)*	9.56 in. *(243 mm)*	

Specifications

Roof Anchor Post Materials

Energy Absorber:	Stainless Steel
Internal Connecting Components:	Stainless Steel
Top and Bottom Post Plates:	Anodized Cast Aluminum
Standing Seam/Wood/Metal Base Plate:	Two-layer Zinc/Powder-Coated Steel
Post Tube:	Zinc/Powder-Coated Steel
Post/Base Plate Seal:	HDPE
Post Cap:	Vinyl w/UV Inhibitor

Connection Components Materials

Standing Seam Clamps:	Anodized Aluminum/Stainless Steel
Extender Bar for Standing Seams:	Anodized Aluminum/Stainless Steel
Hardware for Metal Sheathing:	Hot Dip Galvanized/Neoprene
Hardware for Membrane:	Zinc-Plated Steel/PVC/Neoprene
Hardware for Wood:	Zinc-Plated Steel
Hardware for Concrete:	Stainless Steel

Performance

Activation Force:	1000 lbs. *(4.4 kN)*
Maximum Capacity:	310 lbs. *(140.6 kg)*

Fusion Roof Anchor Post

SKU	Description	Designed to Accommodate
STANDING SEAM ROOFING – Includes post with base and standing seam clamping assembly kit		
X10000	Small base	Standing seam spacing from 11.75 in. *(298 mm)* to 17 in. *(432 mm)*
X10001	Large base	Standing seam spacing from 11.75 in. *(298 mm)* to 21.25 in. *(540 mm)*
X10002	Large base & extension bars	Standing seam spacing from 11.75 in. *(298 mm)* to 24 in. *(610 mm)*
METAL SHEATHING ROOFING – Includes post with base and rivet kit with sealing washers and mastic tape		
X10010	Small base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])*
X10011	Large base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm]).* Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments.
MEMBRANE/BUILT-UP ROOFING – Includes post with base and toggle bolt kit		
X10030	Up to 5.5 in. *(140 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of up to 5.5 in. *(140 mm)*
X10031	> 5.5 in. *(140 mm)* & up to 10.5 in. *(267 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of > 5.5 in. *(140 mm)* up to 10.5 in. *(267 mm)*
WOOD SHEATHING (TEMPORARY INSTALLATIONS ONLY) – Includes post with base and lag screw kit		
X10040	Wood sheathing	Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX
CONCRETE ROOFING – Includes post with base and concrete expansion bolt anchor kit		
X10050	Concrete	Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*
MULTI-PURPOSE METAL SHEATHING, WOOD AND CONCRETE ROOFING (NO HARDWARE INCLUDED) – Includes post with base. Hardware selection is based on the application. See instruction manual for hardware specifications.		
X10020	Metal sheathing, wood or concrete	• Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])* • Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments. • Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX • Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*

Meets or exceeds all applicable industry standards including OSHA, ANSI A10.32 and Z359.1-2007.

This equipment should only be used after reading the manufacturer's instructions. Failure to follow instructions could result in serious injury or fatality.

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LMFRP/0810/30M/RPI

Appendix – B Annotated Design Review Comments

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Public / SBU / FOUO

Comment Report: All Comments
Project: MARFORRES PV Systems Design
Review: Terre Haute Design Analysis 35% Submittal
Displaying 8 comments for the criteria specified in this report.

Id	Discipline	DocType	Spec	Sheet	Detail
5762643	Electrical	Plans	n/a	n/a	PV Panel – Conductors

Comment Classification: **For Official Use Only (FOUO)**

Please provide details in Plans and DA that indicate how the conductors are to be secured, both along the rooftop and down to their controller(s).

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The fastening of conductors and conduits fall under means and methods of electrical and the contractor shalluse the most appropriate means to do so.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762644	Electrical	Plans	n/a	n/a	Utility Disconnect

Comment Classification: **For Official Use Only (FOUO)**

Although the Enphase Micro-Inverter serves as an AC disconnect, you still need to verify with AHJ if a separate, Utility disconnect is required, esp for Fire Dept. Need to verify if this is not required by IEEE. It is covered in 2014 NEC, Article 690.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

A seperate disconnect for the utility compnay is shown on the one line. In addition This disconect may be padlocked by the utility company so we feel it necessary to have another means that is in control of the facility rather than the utility company.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762646	Electrical	Plans	n/a	n/a	Surge Suppression

Comment Classification: **For Official Use Only (FOUO)**

Please include catalog data for surge protection equipment proposed. Consider including a key note in plans that references catalog data, or include particulars on sheet.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The SPD is stated on E-602. also note I have varified with the manufactuer that it comes with an EGC.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762647 Electrical Plans n/a n/a Vdrop – jBox Loc

Comment Classification: **For Official Use Only (FOUO)**

Why are there no details to show locations of jBoxes? Are they always at the 1st PV Panel in the array? Some calcs show a distance from the last PV Panel to the jBox. Is that the longest run of conductors in that circuit?

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The J boxes are shown on the typical detail but would not fit and be legible on the plan views. The voltage drop calcs uses where I feel the J boxes will be placed and give a worst case scenario. The inverter will have to be located next to the module it feeds so this will not change. With he use of less than what the manufactuer sugests as well a temperature correction factor this will give the contractor some flexability in where they are located.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762648 Architectural Cost Estimate n/a n/a n/a

Comment Classification: **Public (Public)**

Please confirm the number of modules on the Drawing adds up to the proposed KW.

Alternate Covered Parking locations to replace the roof mounted modules shown on the Site Plan may be required.

Please contact Justin Runnels 225.573.5024 for more information.

Submitted By: Justin Runnels (2255735024). Submitted On: Aug 13 2014

1-0 Evaluation **Concurred**

Design team confirmed the number of panels adds up to the proposed KW.

Submitted By: Bernard Braddick (405-340-9503) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762649 Electrical Plans n/a n/a PV Array – Load

Comment Classification: **For Official Use Only (FOUO)**

Revisit Panel schedules to verify loads(VA) per array (15ea panels max). Some circuits are showing a load of only 1200VA for a 15-panel array. This seems low, unless the power value I'm using, 264Wac(275Wx0.96,)is too high.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

As staed on the catalog datsheets the inveretr has a max continuous rating of 240W. This is what the panel will see. Also note that the maufacturer states that 24 can be connected but no data was shown to provide a temeprature correction factor so I had to make a judgement call as to how many can go on a circuit.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762651 Electrical Plans n/a n/a PV Array – 1ph vS 3ph

Comment Classification: **For Official Use Only (FOUO)**

It appears, by your labeling convention, that the PV Panels are connected using 2-poles (1phase). However, the Sub-Panels show the PV Panel circuits as 3ph? Is this 1phs-3phs transition occurring at the jBox?

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The inverters are single phase 208V but are wired in such a way that they are three phase 208V as seen by the electrical panel.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762653 Electrical Design Analysis n/a n/a Surge Suppression

Comment Classification: **For Official Use Only (FOUO)**

Please update DA to reflect what is being used to meet lightning protection of solar PV equipment. Many designs simply show surge suppression.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

Lightning protection is not currently in our scope of work for the PV systems, however building with an existing LPS will be provided with a note to extend the lightning protection system in accordance with NFPA 780-2014 considering PV systems were not in the previoud standard 780. For buildings without and LPS no action will be taken since the existing building had not required LPS. However the solar panels are grounded and an SPD at the panel is being provided.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

Appendix – C Structural Calculations and Cut Sheets

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CALCULATIONS - JOLIET

PV system loading to the existing framing system will be evaluated using a methodology that reflects roof-top equipment on existing roofs. This means that 20 psf live load that was included in the original building design will be superceded by 4 psf equipment load plus wind or seismic

Wind forces to the main wind force resisting system (MWFRS) are computed based upon IBC 2012 criteria using allowable stress design.

Basic load combinations per IBC 2012, SECTION 1605.3 include:

D + F

D + H + F + L

D + H + F + (Lr OR S OR R)

D + H + F + 0.75(L) +0.75(Lr OR S OR R)

D + H + F + (0.6W OR 0.7E)

D + H + F + 0.75(0.6W)+ 0.75(L) + 0.75(Lr or S or R)

D + H+ F + 0.75(0.7E) +0.75L + 0.75S

0.6D + 0.6W + H

0.6 (D + F) +0.7E +H

The above excludes exceptions per 1605.3.1

Main Reserve Center

New solar panel array per arch. layout

Added loads to the existing building from solar panels:

D = 4 psf (sunmodule + Renusol mounting rails)

W = 27.28 psf (Y-Y); 26.54 psf (X-X) (MWFRS) see wind analysis

R = 0 (rain)

H = 0

F = O

L = 0

Lr = 20 PSF BETWEEN SOLAR PANEL ARRAY BUT Lr=0 WHERE SOLAR PANELS

S = 20 psf (roof snow)

Consider worse case -Y-Y: D + 0.6W = $4+(.6\cdot(27.28))=20.37$ psf

(This is the vertical wind pressure normal to the ridge)

Consider worse case X-X: D + 0.6W = $4+(0.6\cdot 26.54)=19.92$ psf

(This is the horizontal component of wind pressure normal to ridge)

The bar joist roof rafters, sloped 2.5V:12H and spaced 5'-0" c/c are supporting 22ga. Type B roof decking which is supporting rigid insulation, vapor retarder, ice/water shield, and standing-seam roof panels, typically 2" seam. The load path from the rail of the solar panel moves across the gap of 6" to the 22ga. metal roof deck. Fasteners to the roof deck and bar joists will need to be able to transfer the lateral forces properly to the roof rafters

The lateral wind force resisting system is currently accomplished with shear walls, either cmu or precast concrete. Roof diaphram to the shear walls is through the 22ga. metal deck.

PV panel = sunmodule panel 39.41 x 65.94 x 1.22

Maximum force to shear panels is at the drill / gym hall area:

$$F\ (wh) = \left(40 \cdot \left(3 \cdot \frac{65.94}{12}\right) \cdot 26.54 \cdot .208\right) = 3640.1\ \text{lbs}$$

$$F\ (wv) = \left(40 \cdot \left(3 \cdot \frac{65.94}{12}\right) \cdot 27.27\right) \cdot \frac{3}{12} = 4495.46\ \text{lbs}$$

Consider Renusol Rail Section properties about centroid:

This is aluminum 6063-T6 grade with an allowable Fb=14.32 ksi with an unbraced length of the compression side = 6 ft.

Sx = 0.33148 in.^3 r(x) = 0.83364 in.
Sy = 0.19985 in.^3 r(y) = 0.50589 in.
A = 0.56739 sq. in.
height = 2.361 in.

Using clip spacing directly over roof joists at 5'-0" c/c and rail spacing under solar panels of 3'-0" c/c :

Rails -

$$M(x) = \frac{\left(27.27 \cdot \frac{3}{2}\right) \cdot 5^{2}}{8} = 127.83 \text{ ft-lbs}$$

$$f\,(bx) = \frac{127.83 \cdot 12}{0.33148} = 4627.61 \text{ psi} < 14{,}320 \text{ psi, say o.k.}$$

$$M\,(y) = \frac{26.54 \cdot \frac{3}{2} \cdot 5^{2}}{8} = 124.41 \text{ ft-lbs}$$

$$f\,(by) = \frac{124.41 \cdot 12}{0.19985} = 7470.2 \text{ psi} < 14{,}320 \text{ psi, say o.k.}$$

If the connection clip is positioned by the installer between existing roof purlins and not directly over purlins:

Use Unistrut P5000 shape

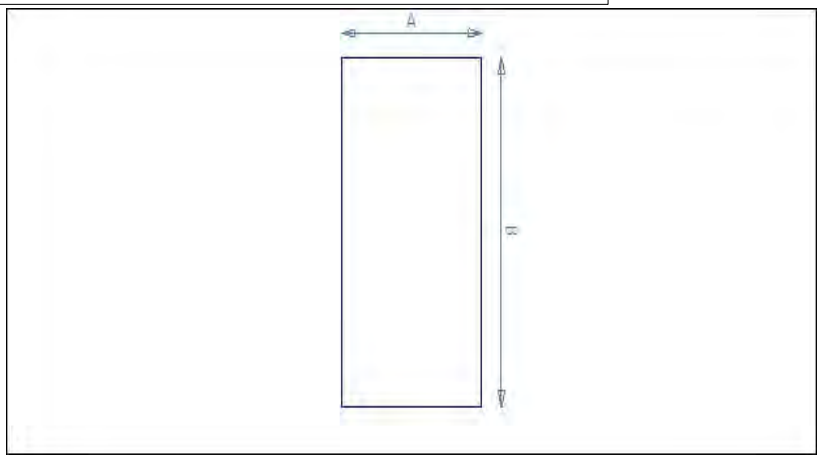
Company:	Dunlap associates	**Date:**	Thu, May 29 14
Address:	3340 Blue Springs Rd, #503B		
Country:	United States		
State:	Georgia		
Zip:	30144		

Load Generator Report

Input

Building Data

Load Code	2012 IBC w/ ASCE 7-10



Building Template Dimensions:

Dimension	Value
A (ft)	30
B (ft)	60
C (ft)	N/A
D (ft)	N/A
E (ft)	N/A
F (ft)	N/A

Location:

Zip Code	47807
Address	47807 TERRE HAUTE, IN

Geometry :

Building Width (ft)	60
Building Length (ft)	30
Ridge Height (ft)	21.67
Eave Height (ft)	11.67
Mean Height (ft)	16.67

Stories :

Number of Stories	1

Floor	Story Height (ft)
Roof	11.67

Roof :

Roof Type	Roof Angle (degrees)	Roof Slope (X/12)	Overhang	Parapet	Parapet Height (ft)
Gable	18.435	4	No	N/A	N/A

Design Parameters :

Risk Category:	II

*** Ridge direction is considered parallel to Building length, switch building dimensions if needed for proper ridge orientation.**

Wind Data

Wind Load Data :

Exposure	C
Basic Wind Speed (mph)	115
GCpi	(+0.18)(-0.18)
Kzt	1
Kd	0.85
Building Corner Distance a (ft)	3

Component and Cladding Wall and Roof Data :

Wall Effective Area (ft²)	275
Roof Effective Area (ft²)	100
Overhang Effective Area (ft²)	N/A
Parapet Effective Area (ft²)	N/A

Wind-Blowing Story Area:

Story	Story Area Facing X dir.(ft²)	Story Area Facing Y dir.(ft²)
Roof	700.2	350.1

Seismic Data

Common Seismic Data :

Basic System Category	Building Frame Systems
Basic System	Buckling-restrained braced frames, moment-resisting beam-column connections

Building height limits for Seismic Design Categories (ft) :

A,B	C	D	E	F
NL	NL	160	160	100

Design Coefficients and factors :

R	Omega	Cd	CT	x	Site Class
8	2.5	5	0.028	0.8	C

Design Requirements :

Ss(%g)	S1(%g)	Fa	Fv	TL (sec)
33.136	11.354	1	Calculated	12

Loads:

Floor	Area (ft²)	Dead Ld. (psf)	Part Live Ld. (psf)	Partition Ld. (psf)	Equipment Ld. (psf)	Part Snow Ld. (psf)
Roof	1800	60	0.000	10	0.000	0.000

Snow Data

Ground Snow Load (psf)	20
Roof Surface Type	All Other Surfaces

Terrain Category and Roof Exposure :

Roof Exposure	Fully Exposed
Terrain Category	C

Thermal Condition	Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25 °F × h × ft²/Btu (4.4 K × m²/W)

Output

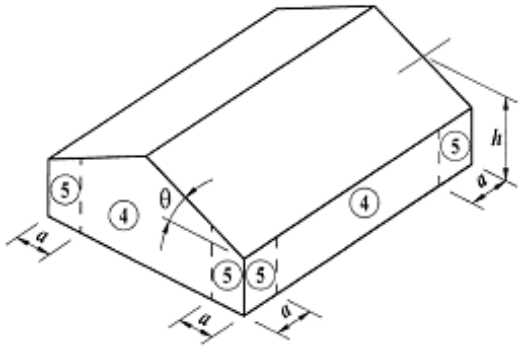
Wind Output

Component and Cladding:

Walls :

Zone 4		
GCp	**P (+GCpi) (psf)**	**P (-GCpi) (psf)**
0.7458	14.133	23.125
-0.8458	-25.623	-16.631

Zone5		
GCp	**P (+GCpi) (psf)**	**P (-GCpi) (psf)**
0.7458	14.133	23.125
-0.8916	-26.767	-17.775

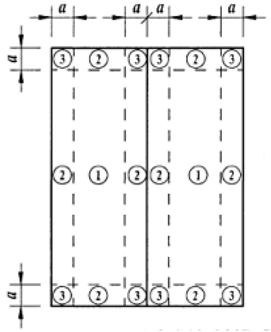


Note: Illustration may not represent actual building roof type

Roofs :

Windward :

Zone	GCp	P (+GCpi) (psf)	P (-GCpi) (psf)
Zone 1	0.3	2.997	11.989
Zone 2	0.3	2.997	11.989
Zone 3	0.3	2.997	11.989



Leeward :

Zone	GCp	P (+GCpi) (psf)	P (-GCpi) (psf)
Zone 1	-0.8	-24.478	-15.486
Zone 2	-1.2	-34.469	-25.477
Zone 3	-2	-54.452	-45.460

MWFRS :

Walls :

Wind Load in X Direction :

Windward Cp	0.8	**Leeward Cp**	-0.5	**Side wall Cp**	-0.7

Height (ft)	Windward P(+GCpi) (psf)	Windward P(-GCpi) (psf)	Leeward P(+GCpi) (psf)	Leeward P(-GCpi) (psf)	Side wall P(+GCpi) (psf)	Side wall P(-GCpi) (psf)
5.835	12.116	21.108	-15.112	-6.120	-19.358	-10.366
11.67	12.116	21.108	-15.112	-6.120	-19.358	-10.366

Wind Load in Y Direction :

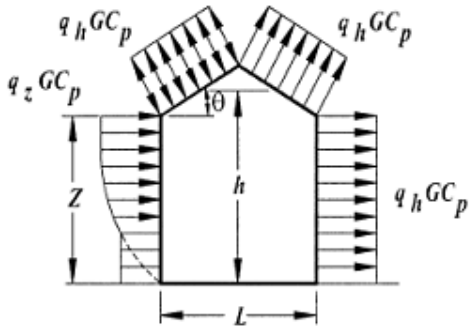
Windward Cp	0.8	Leeward Cp	-0.3	Side wall Cp	-0.7

Height (ft)	Windward P(+GCpi) (psf)	Windward P(-GCpi) (psf)	Leeward P(+GCpi) (psf)	Leeward P(-GCpi) (psf)	Side wall P(+GCpi) (psf)	Side wall P(-GCpi) (psf)
5.835	12.116	21.108	-10.865	-1.873	-19.358	-10.366
11.67	12.116	21.108	-10.865	-1.873	-19.358	-10.366

Roofs :

Parallel to ridge wind load values :

Cp	Horizontal Distance (ft)	P(+GCpi) (psf)	P(-GCpi) (psf)
-0.9246	0 to h/2	-24.127	-15.135
-0.8777	h/2 to h	-23.131	-14.139
-0.5223	h to 2h	-15.584	-6.592
-0.3445	> 2h	-11.811	-2.819



ELEVATION

Note: Illustration may not represent actual building roof type

Normal to ridge wind load values :

Windward wind load values :

Cp	P(+GCpi) (psf)	P(-GCpi) (psf)
0.1158	-2.037	6.955
-0.3772	-12.505	-3.513

Leeward wind load values :

Cp	P(+GCpi) (psf)	P(-GCpi) (psf)
-0.5687	-16.570	-7.578

Story Lateral Load :

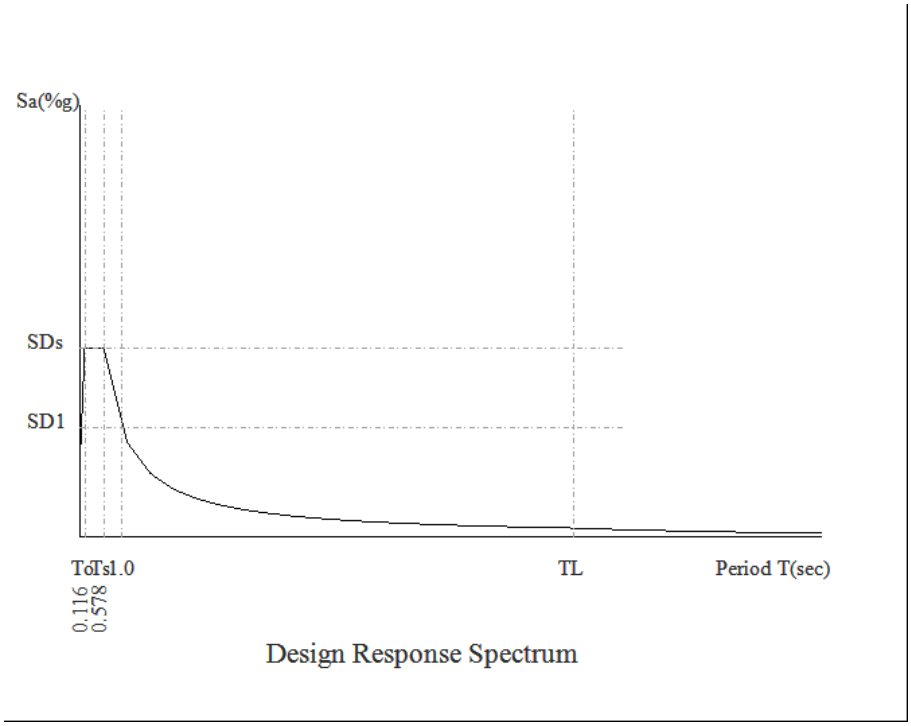
Lateral Wind Load in X Direction :

Floor	Design Pressure (psf)	Lateral Load (lbs)
Roof	27.227	17812.38
Total		17812.38

Lateral Wind Load in Y Direction :

Floor	Design Pressure (psf)	Lateral Load (lbs)
Roof	22.981	6422.817
Total		6422.82

Seismic Output



Design Response Spectrum

Design Parameters :

Importance Factor	1	**Fa**	1	**SDs**	0.2209	**Cs**	0.0276	**V (lbs)**	3479.3
SDC	B	**Fv**	1.6865	**SD1**	0.1277	**T (sec)**	0.2659	**W (lbs)**	126000

Stories :

Floor	Base Height (ft)	Gravity Ld. (lbs)	Cvx	Floor Force (lbs)	Cumulative Shear (lbs)
Roof	16.67	126000	1	3479.28	3479.28

Snow Output

Roof Snow Load (psf)	13.86
Thermal Factor (Ct)	1.1
Roof Slope Factor (Cs)	1

Renusol VS

Installation Guide

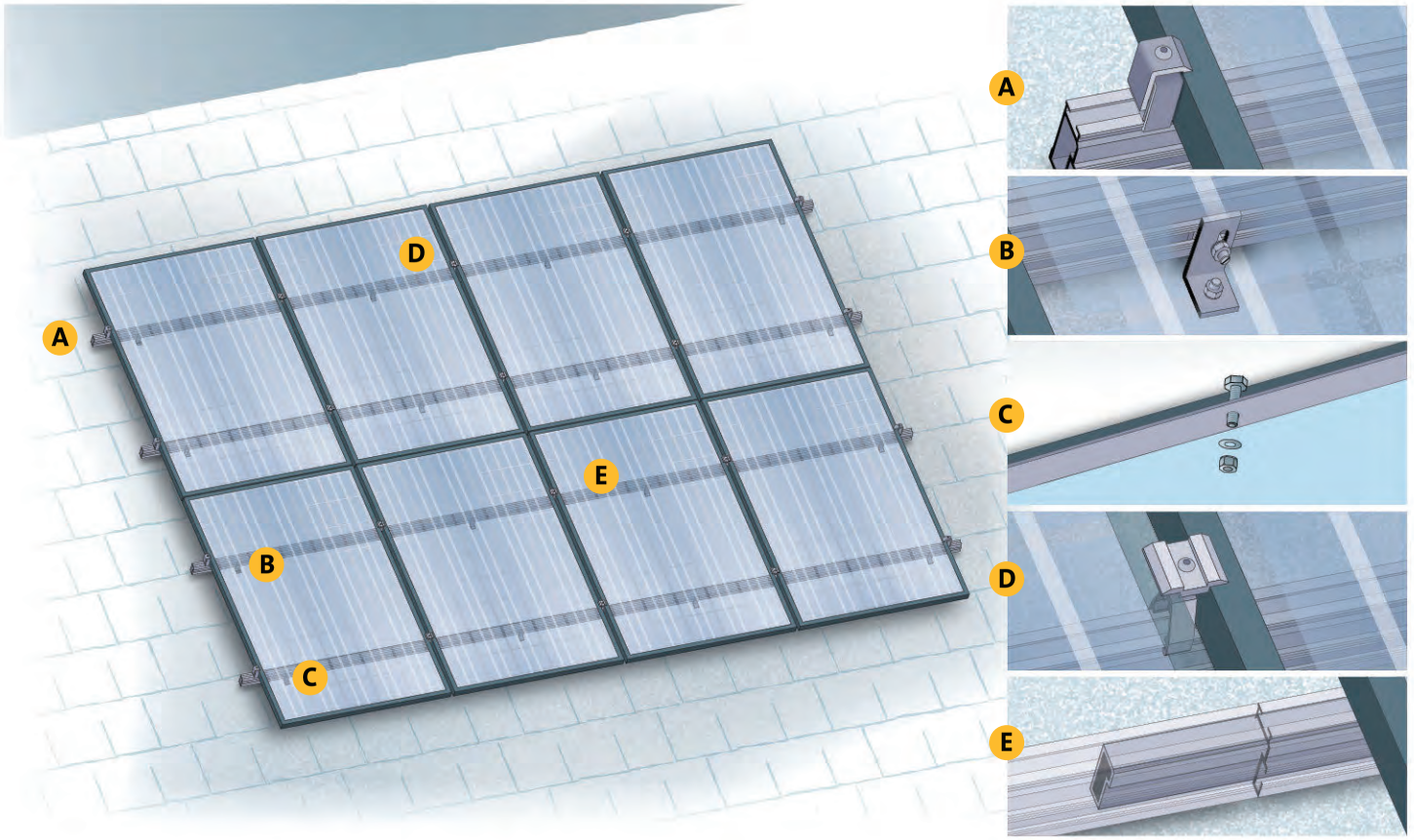
OVERVIEW

The Renusol VS racking system has been developed for easy installation of solar pv system on pitched roofs. It includes proprietary "one size fits all" clamps for all module thicknesses ranging between 31-51 mm.

Please refer to VS Design Guide for system layout and grounding instructions.

Please read this guide carefully before starting the installation. Always follow proper safety precautions. Be sure to check local building codes to ensure compliance.

Please check for the latest version of the installation guide at www.renusolamerica.com.

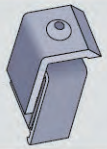


REQUIREMENTS

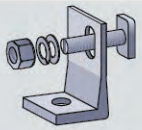
1. 5 mm Allen (hex) wrench
2. 13 mm open-end wrenches and/or sockets and rachets
3. 7/16" open ended wrenches
4. Code compliant flashing to attach L-feet to roof
5. WEEB-CCR grounding washer

SYSTEM COMPONENTS LIST

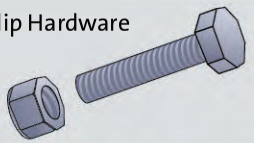
A End Clamp



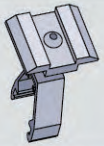
B L-Foot



C Anti-slip Hardware

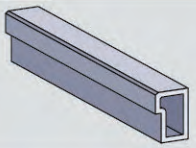


D Middle Clamp



E Renusol VS Rail

F Rail Splice Connector

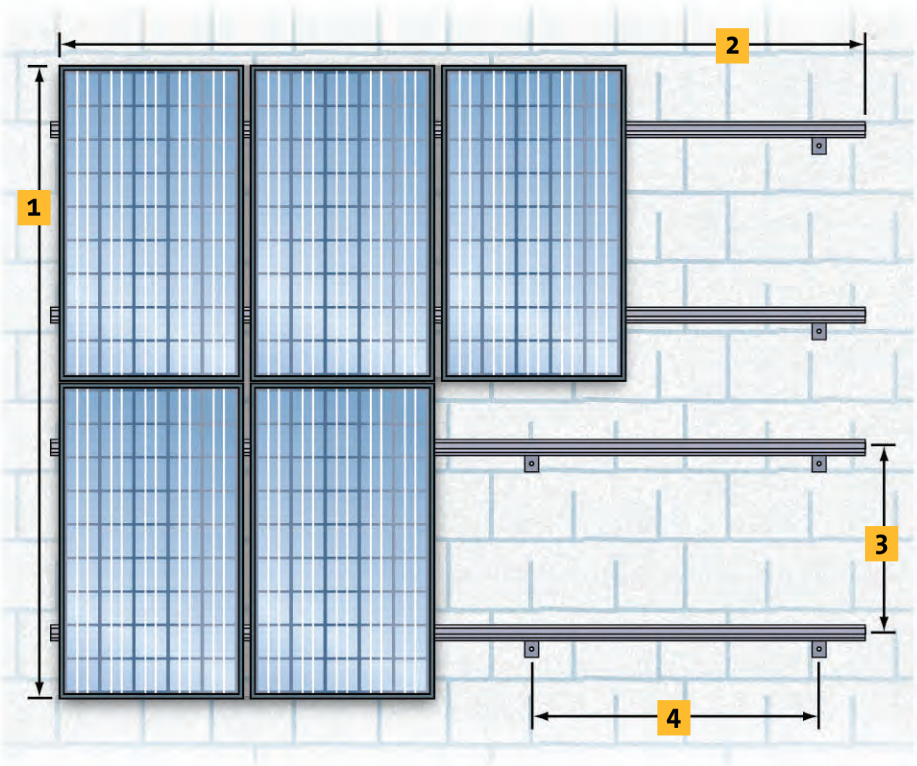


Renusol
Solar Mounting Systems

Renusol VS

Installation Guide

LAYOUT



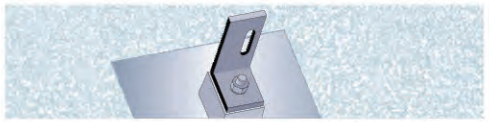
Plan the layout of the components per the dimensions below:

1. Quantity of modules in the vertical direction x (module length + 0.75")
2. Quantity of modules in the horizontal direction x (module width + 0.75") + 2.50"
3. Approximately 2/3 to 3/4 of the module length (please refer to module manufacturer's specifications)
4. For spacing of mounting brackets, please refer to the Renusol VS Design Guide. Note that one mounting bracket should be used near each splice connection.

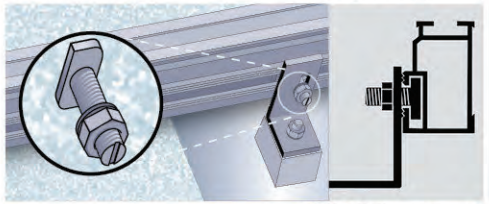
Renusol Solar Mounting Systems

Renusol America
1292 Logan Circle NW, Atlanta, GA 30318
www.renusolamerica.com
+1 877-847-8919

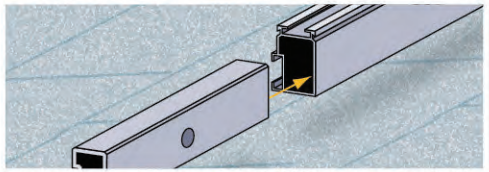
ASSEMBLY



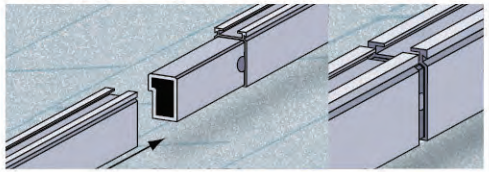
Step 1: Flashing and L-feet
Install code compliant flashing per the manufacturer's instructions and attach L-feet.



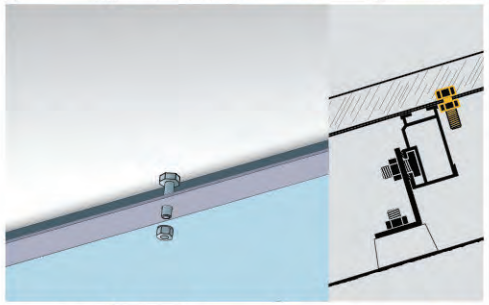
Step 2: Rails
Attach the rails to the L-feet using the T-bolts and nuts. To ensure the T-bolts are properly aligned, make sure the line on the end of the T-bolt is perpendicular to the rail. Tighten to 10 ft-lbs.



Step 3: Splice Connectors
Splice connectors are required to connect rails together. Slide a splice connector into the first rail until the head of the rivet stops the splice connector.

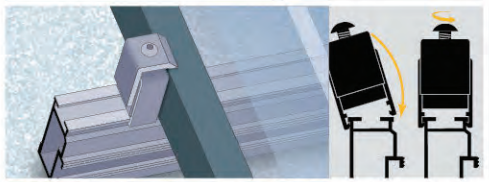


Step 4: Splice Connectors
Slide the end of the second rail over the splice connector until the rivet head stops the splice connector. There will be a slight gap between rails for thermal expansion.

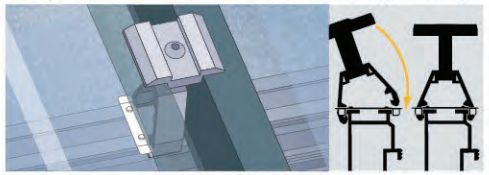


Step 5: Anti-slip Protection
Before installing the bottom row of modules, anti-slip hardware could be added for protection. To do this, attach two ¼-20 bolts and nuts through the pre-drilled holes in the module frames.

Lay the modules on the bottom row of rails so the anti-slip hardware rests against the inside edge of the bottom rail.



Step 6: End Clamps
Snap the end clamps about 1/2" from the end of the rails. Secure the modules by turning the 5mm Allen bolt, tighten to 8 ft-lbs.



Step 7: Middle Clamps
Place WEEB-CCR onto rail. Snap middle clamps over WEEB and onto rails, slide against the module. Slide next module against middle clamp, tighten to 10 ft-lbs.

Note: When using anti-sieze, the torque setting should be reduced to 5 ft-lbs for both End Clamps and Mid Clamps.

Appendix – D Basis of Design: Covered Parking

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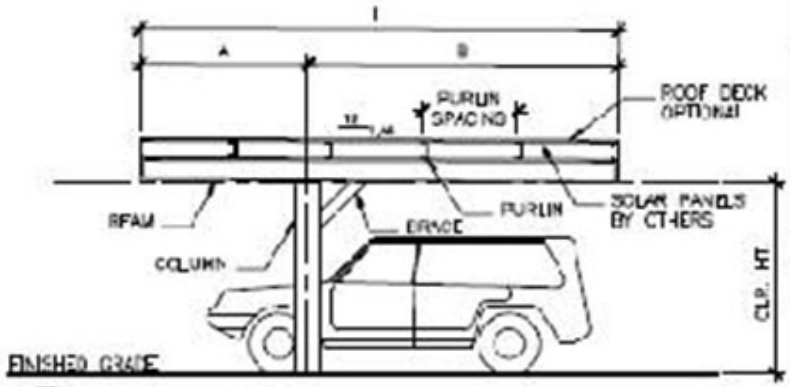
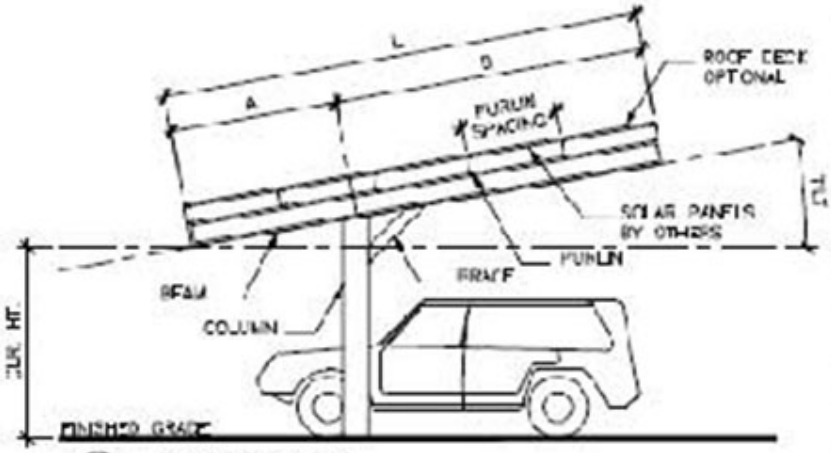
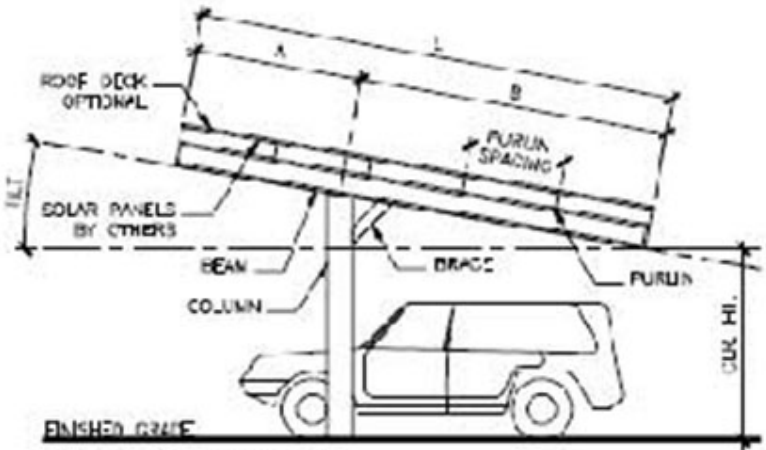


1 CROSS SECTION
BSP FLAT SLOPE



2 CROSS SECTION
BSP UP SLOPE

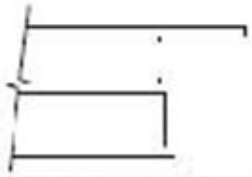


3 CROSS SECTION
BSP DOWN SLOPE

SPECIFICATIONS

L – (MAX. 24')
D – (2/3L MAX.)
A – (L–D)
PURLIN SPACING –
TILT – (IN DEGREES)
MIN. CLEAR LIGHT –
LIGHT SAVE – HIGH SAVE = CLR HT + 15" + LSW (ILL)
PANEL GAP (IF ANY) –
PORTRAIT: OR, LANDSCAPE: SOLAR PANEL
ROOF DECK (OPTIONAL) –
CANTILEVER (OPTIONAL) –
HANDICAP SPACE (OPTIONAL) –

NOTES



OPTIONAL SOLAR PANEL CANTILEVER
NTS

BAJA CONSTRUCTION CO., INC.
223 FOSTER ST., MARTINEZ CA 94553
1-800-366-8600 FAX: (925) 229-0151

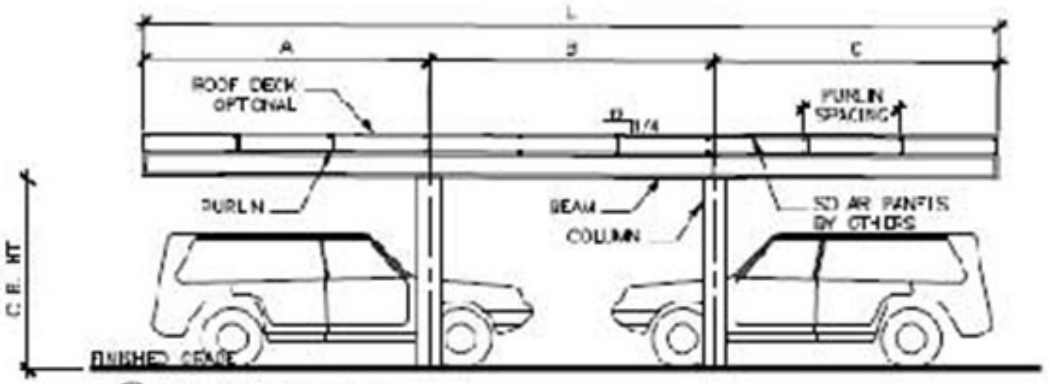
SOLAR SUPPORT SYSTEM
BRACED SINGLE POST

PROJ. NO.

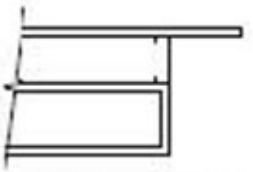
SHT. 1

SPECIFICATIONS
_ = (MAX. 40')
B = (2/3L MAX.)
A = (_–B)
PURLIN SPACING =
TILT – (IN DEGREES)
MIN. CLEAR HIGH –
HIGH EAVE –
HIGH EAVE = CLR HT + 18" + _SW (MIN)
PANEL GAP (IF ANY) –
PORTRAIT: OR, LANDSCAPE:
SOLAR PANEL
ROOF DECK (OPTIONAL) =
CANTLEVER (OPTIONAL) =
HANDICAP SPACE (OPTIONAL) =

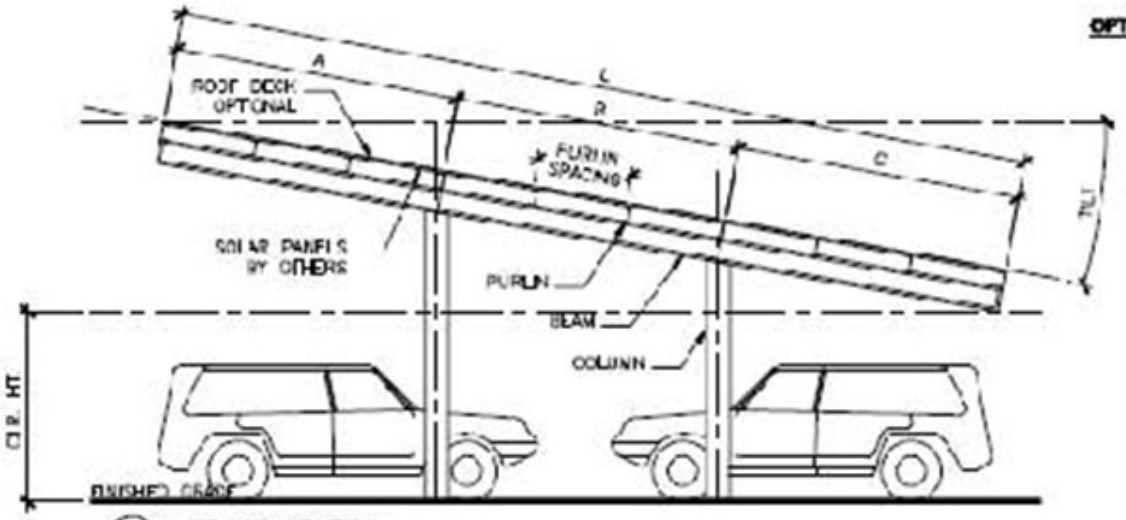
NOTES



1 CROSS SECTION
BSP BACK TO BACK FLAT SLOPE NTS



OPTIONAL SOLAR PANEL CANTLEVER
NTS



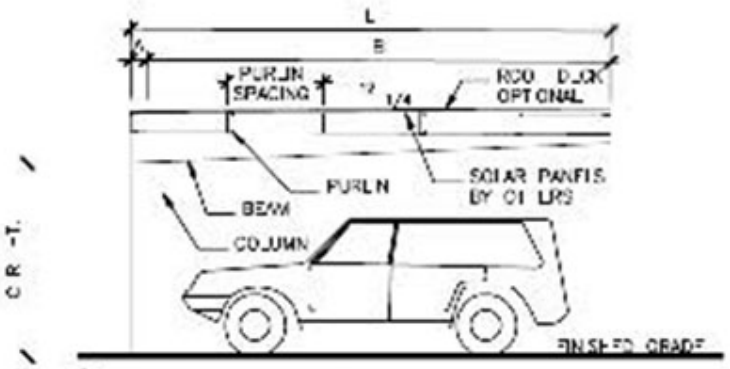
2 CROSS SECTION
BSP BACK TO BACK SLOPED NTS

BAJA CONSTRUCTION CO., INC.
223 FOSTER ST., MARTINEZ CA 94553
1-800-966-6600 FAX: (925) 228-0101

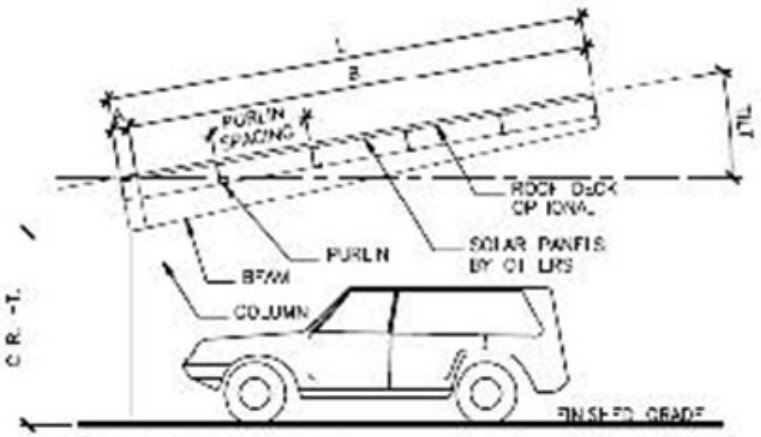
SOLAR SUPPORT SYSTEM
SINGLE POST BACK TO BACK

PROJ. NO.

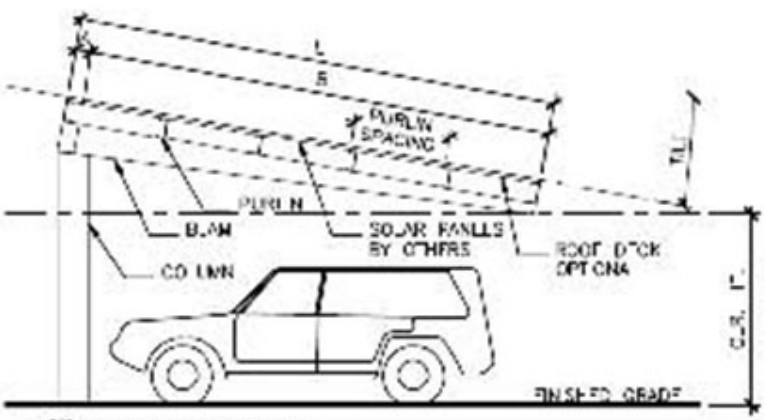
SHT. 2 OF 4



1 CROSS SECTION FOR FLAT SLOPE



2 CROSS SECTION FOR UP SLOPE



3 CROSS SECTION FOR DOWN SLOPE

SPECIFICATIONS

L – (MAX. 20')

B – (2/3 MAX.)

A = (L–B)

PURLIN SPACING –

TILT – (IN DEGREES)

MIN. CLEAR HEIGHT

LOW EAVE –

HIGH EAVE – CLR-T 18" SW (TLT)

PANEL CAP (IF ANY)

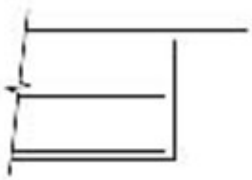
PORTRAIT: OR, LANDSCAPE:
SOLAR PANEL

ROOF DECK (OPTIONAL) –

CANTILEVER (OPTIONAL)

HANDICAP SPACE (OPTIONAL) –

NOTES



OPTIONAL SOLAR PANEL CANTILEVER

BAJA CONSTRUCTION CO., INC. 223 FOSTER ST., MARTINEZ CA 94553 1-800-366-9600 FAX: (925) 229-0161	SOLAR SUPPORT SYSTEM FULL CANTILEVER		SHT. NO. 3

SPECIFICATIONS

L – (MAX. 40')

B – (2/3_ MAX.)

A = (_–B)

PURL N SPAC NG –

T_" – (N DEGREES)

M N. C_AR IC I =

HIGH -AVE –
I SI LAL = OUR II I 18" .2M (1L)

PANE_ GAP (IF ANY)

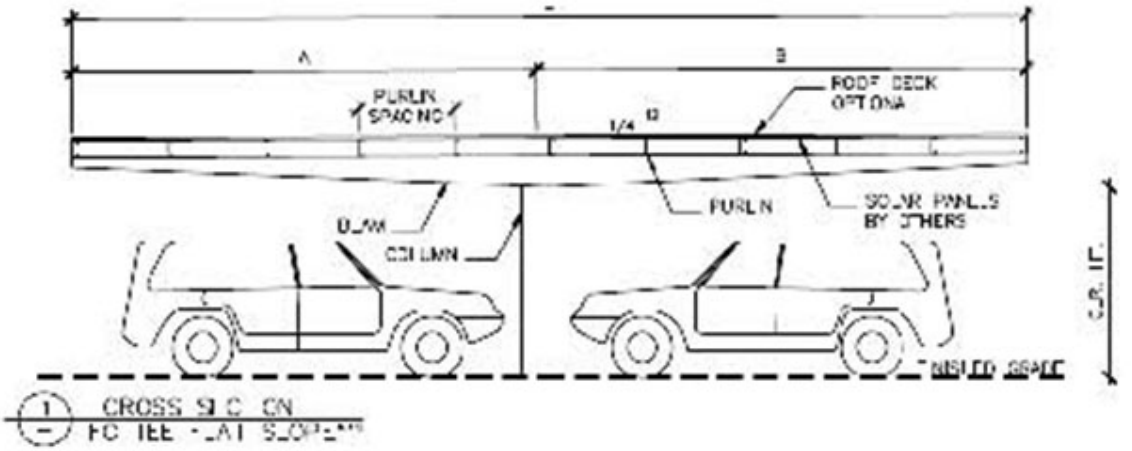
PORTRAI : OR, ANDSCAPI :
SOLAR PAN

ROOF DECK (OP ONA_) –

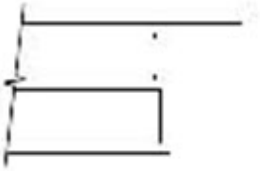
CANTI EVER (OPT ONA)

HAND CAP SPACI (OPTIONA) –

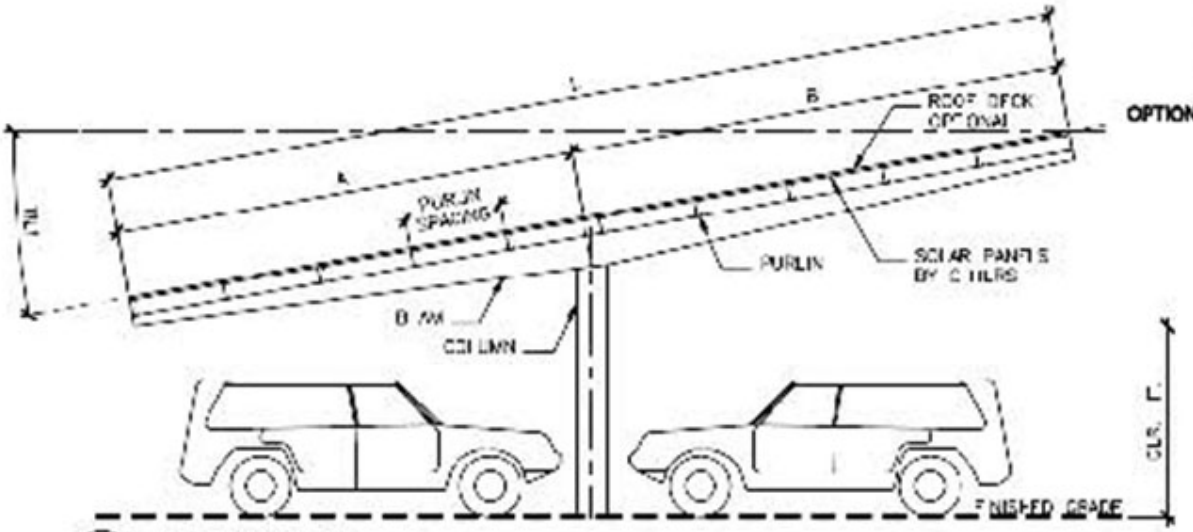
NOTES



1 CROSS SEC ON
FC TEE FLAT SLOPE

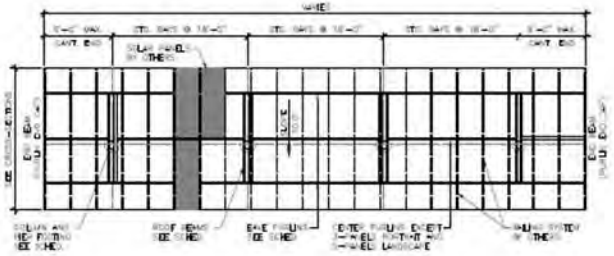


OPTIONAL SOLAR PANEL CANTILEVER



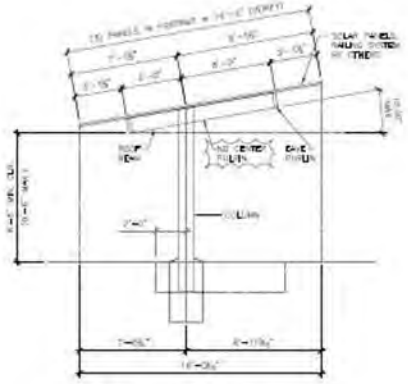
2 CROSS SEC ON
FC TEE SLOPED

BAJA CONSTRUCTION CO., INC. 223 FOSTER ST., MARTINEZ CA 94553 1-800-366-9600 FAX: (925) 229-0161	**SOLAR SUPPORT SYSTEM** FULL CANTILEVER TEE		SHT. NO. 4

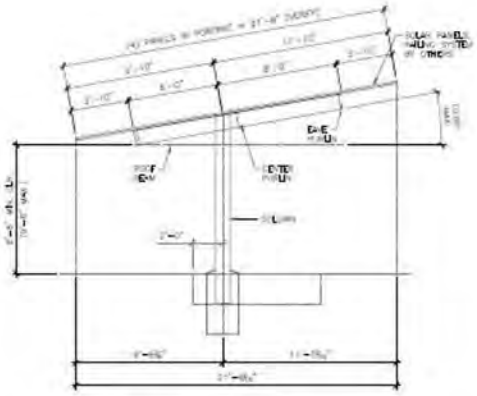


FRAMING & FOUNDATION PLAN

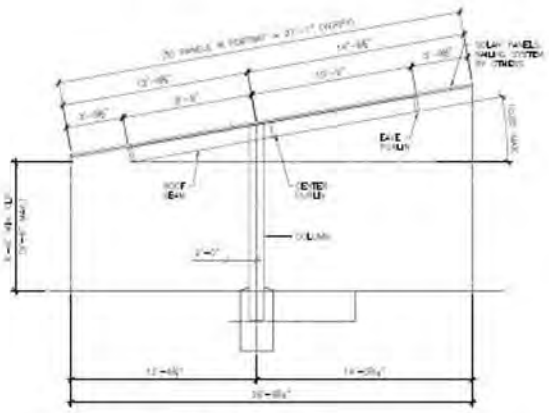
COLUMNS AT LOW END



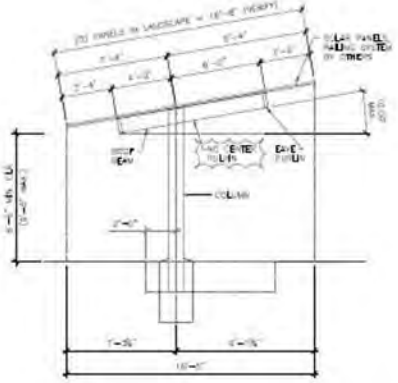
CROSS-SECTION
3-Panels Portrait



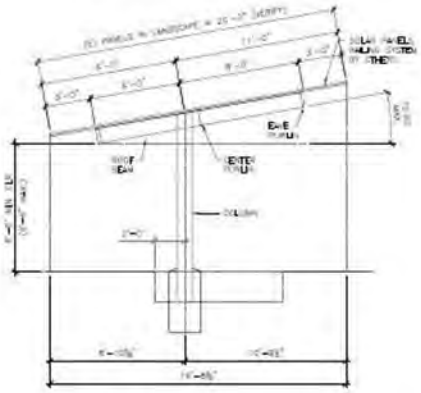
CROSS-SECTION
4-Panels Portrait



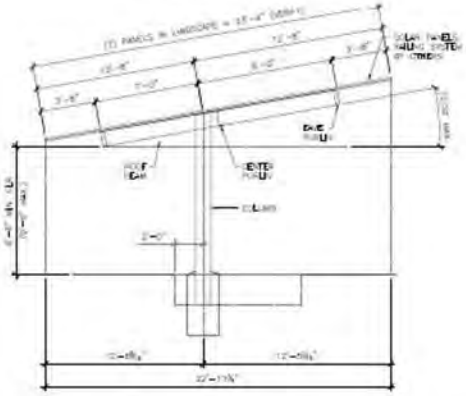
CROSS-SECTION
5-Panels Portrait



CROSS-SECTION
5-Panels Landscape



CROSS-SECTION
6-Panels Landscape



CROSS-SECTION
7-Panels Landscape

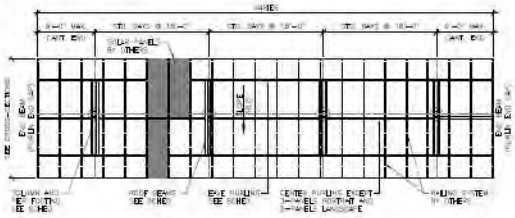
TYPICAL FRAMING PLAN
(Columns at Low End)

PROPOSED STANDARDS
SOLAR SUPPORT STRUCTURES
3/4/5 Panels Portrait - 5/6/7 Panels Landscape
for

BAJA
CONSTRUCTION CO., INC.
923 FOSTER ST., MARTINEZ CA 94553
1-800-366-9900 FAX: (925) 229-0161

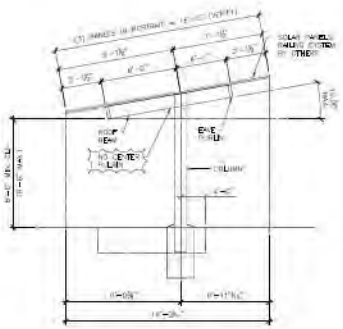
CEnergy	01/05/12
FRL	R.P.

SHT
S-1
1 OF 2

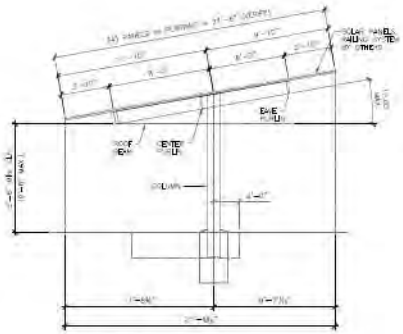


FRAMING & FOUNDATION PLAN

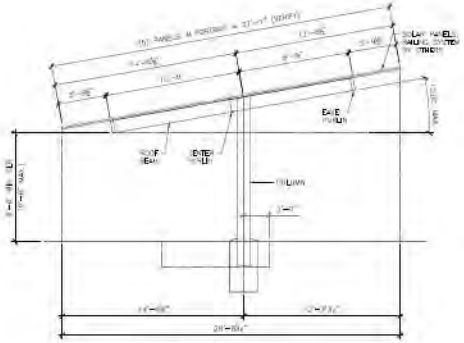
COLUMNS AT HIGH END



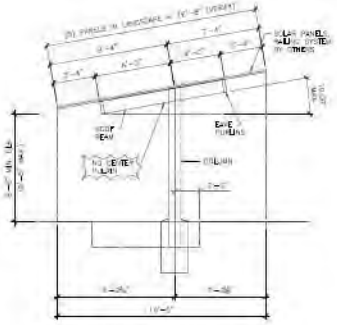
CROSS-SECTION
3-Panels Portrait



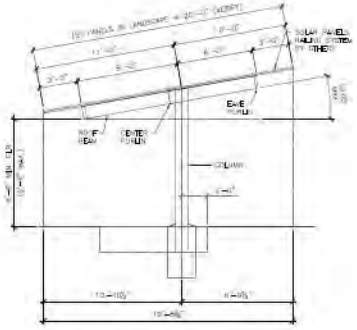
CROSS-SECTION
4-Panels Portrait



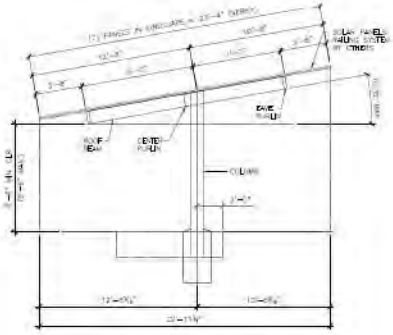
CROSS-SECTION
5-Panels Portrait



CROSS-SECTION
5-Panels Landscape



CROSS-SECTION
6-Panels Landscape



CROSS-SECTION
7-Panels Landscape

TYPICAL FRAMING PLAN
(Columns at High End)

PROPOSED STANDARDS
SOLAR SUPPORT STRUCTURES
3/4/5 Panels Portrait - 5/6/7 Panels Landscape
Inc

BAJA
CONSTRUCTION CO., INC.
23 FOSTER ST., MARTINEZ, CA 94553
1-800-999-9999 FAX (925) 229-0161

JOB NO.	DATE
CEnergy	01/09/12
DRAWN	CHECKED
FRL	R.P.

SHEET
S-2
2 OF 2

Appendix – E PV System – Shadow Analysis/Site Plan

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PV PANELS ON FRAME MOUNTED SYSTEM, ON PITCHED ROOFS, TYP.
PV PANELS ON BALLASTED SYSTEM, ON FLAT ROOFS, TYP.
A/E TEAM RECOMMENDS TRIMMING TREE
BID ALTERNATE: PV PANELS LOCATED ON COVERED PARKING STRUCTURES
90'-0"
81'-0"
S Fruitridge Ave

TOTAL NUMBER OF PANELS SHOWN = 295

315 MAXIMUM PANELS

TRUE NORTH

PLAN NORTH

1 **SHADOW ANALYSIS - SITE PLAN**

NOT TO SCALE:

SYM	DESCRIPTION	DATE	APPR

Designed By: Bernard Braddick
Drawn By: Bernard Braddick
Checked By: Eric Morehouse
Submitted By: Rick Wente

DEPARTMENT OF THE ARMY
US ARMY CORPS OF ENGINEERS
FORT WORTH, TEXAS

BLAIRREMY & COMPANY ARCHITECTS
3 MOCKY MANTLE DR. ZIP# PLACE STE 330
OKLAHOMA CITY, OK 73134 PH: (405)348-4455
20 North Wacker Drive, Suite 2200, Chicago, IL 60606

MRF TERRE HAUTE
TERRE HAUTE, IN
Solar Photovoltaic System

SHADOW ANALYSIS - SITE PLAN

Sheet Reference Number
A-100
Sheet of

UNREVIEWED - NOT FOR CONSTRUCTION

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US Army Corps of Engineers
Fort Worth District
819 Taylor Street
P.O. Box 17300
Fort Worth, TX 76102

Marine Corps Reserve

MFR Terre Haute

80kW Photovoltaic System
PV Designer Report

May 2, 2014

Prepared by

Merrick & Company
3575 Koger Blvd
Duluth, GA 30096
(404) 739-5100

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APPENDICES

Appendix A – PV Module Space Calculation – Flat Roof

Appendix B – Catalog Cut Sheets

Appendix C – Payback Calculation

Executive Summary

The Photovoltaic (PV) System to be installed at this project site is to provide a minimum 80kW output. The calculated output of the designed layout is 80kW, as shown in the PV Designer Report - Summary section of this report. The PV collection modules to provide this output will be installed on Roof Systems #1 through #5 as depicted in the Site Plan section of this report. Each roof system was evaluated in its ability to produce power based on the azimuth facing and panel tilt. The placement of PV modules on roof system was prioritized on roof system with higher efficiencies and with lower priority on lower roof efficiencies. The order of roof system efficiencies are Roof #5, Roof #4, Roof #3, Roof #4, and last is Roof #2.

The site is heavily wooded where tree where trees located on the east side of the site had a major impact to site selection of PV modules. There are two trees immediately south of the main building where one of the trees appears to be a mature tree while the 2nd tree has yet matured and expected to have a major impact to roof system #1, #2. The placement of PV module has taken into consideration that both trees will be matured before the end of life of the PV array; therefore, module were adjusted accordingly.

Panels mounted on the flat roof will be installed at a 10-degree angle, with a spacing of 23 inches minimum between modules. Panels mounted on the Main Building roof are installed flat against the existing slope of the roof.

The PV modules selected for this installation are the SolarWorld Model Protect SW 275, connected through Enphase Energy inverters, Model M250. The de-rating factor for all modules installed under this project is 0.76. The system payback calculations for this project site will be calculated after the construction cost for this site is estimated.

The average monthly energy usage for the Terre Haute site is approximately 30,907-kWH with an average cost of $0.10/kWH. The 80kW-DC rated system will produce a monthly average of 6707-kWH thereby reflecting an estimated average reduction of 21.7% in energy demand from the local power company. Northern Indiana Public Service Company (NIPSCO) offers performance-based incentive of $0.26/kWH for a contract length not to exceed 15 years. Terre Haute power provider is Duke Electric and the performance-based incentive may not be available for Terre Haute. Otherwise, the payback increases to 52 years. NIPSCO has been contacted to confirm eligibility.

Project Site Plan

Site Plan – Marine Corps Reserve Center Terre Haute, Indiana

PV Designer Report - Summary

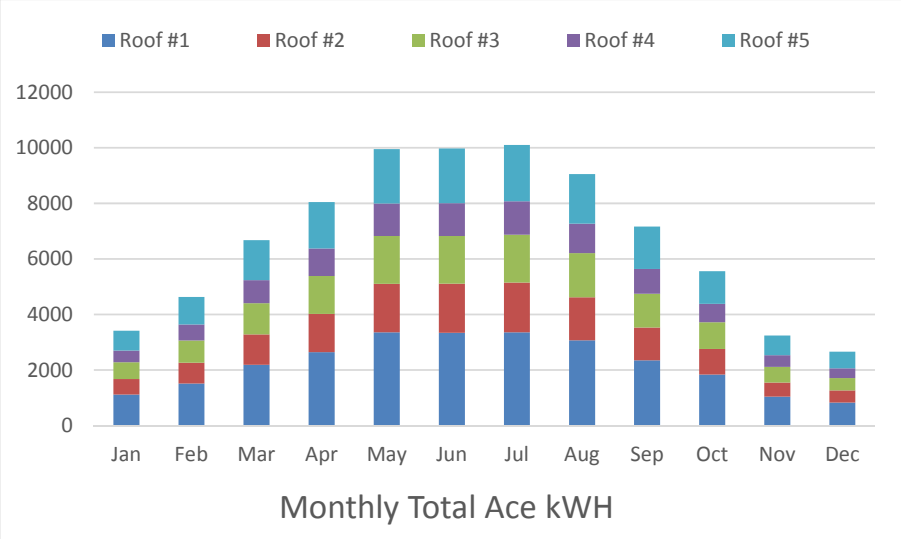
Terre Haute System Summary:

Name: Terre Haute
Location: 39.50 °N, 87.40 °W
Minimum Temperature: -30.00 °C
Maximum Temperature: 44.44 °C

Weather Properties:

Station Name: INDIANAPOLIS
Data Source: TMY2-93819
Location: 39.73 °N, 86.28 °W
Distance From Session Location: 61.76 mi

Month	Roof #1	Roof #2	Roof #3	Roof #4	Roof #5	Combined Total
Jan	1116.2	558.4	602.3	423.4	712.7	3413
Feb	1512.7	749.3	798.8	577.4	989.8	4628
Mar	2184.8	1095.4	1128.8	829.8	1441.8	6680.6
Apr	2638.4	1379.6	1363.5	992.3	1676.4	8050.2
May	3355.9	1744.8	1726.1	1167.1	1958	9951.9
Jun	3338.6	1765.1	1719.6	1180.1	1977.5	9980.9
Jul	3354.6	1793.7	1724.9	1203.4	2027.1	10103.7
Aug	3068.9	1548	1589.8	1059.8	1784.4	9050.9
Sep	2348.6	1180.3	1211.6	894.7	1529.5	7164.7
Oct	1838.7	921.3	960.4	661.9	1173.9	5556.2
Nov	1042.7	509.3	562	414.9	710.4	3239.3
Dec	828.5	435.7	441.2	355.3	603	2663.7
Annual	26628.6	13680.9	13829	9760.1	16584.5	80483.1
# Modules	50	52	97	35	57	291
kWp	13.75	14.3	26.675	9.625	15.675	80.025



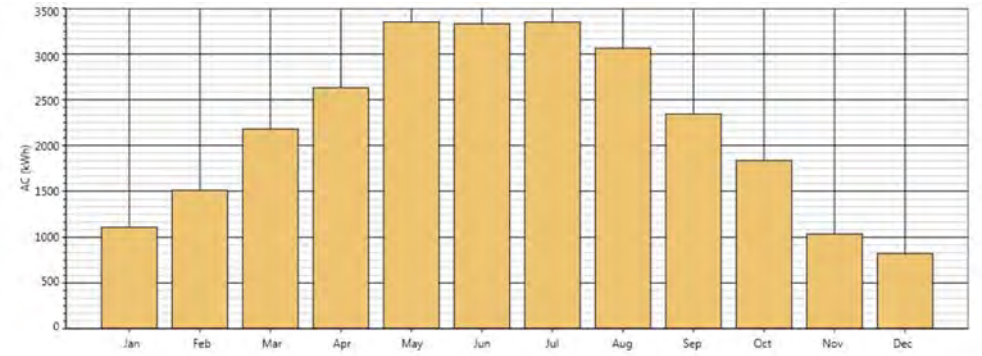
Roof #1 Design

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Custom
Inverter Model: Enphase Energy
(Due to spacing constraints, only the manufacturer and model of the first inverter is included in this report) Derate Factor: 0.76

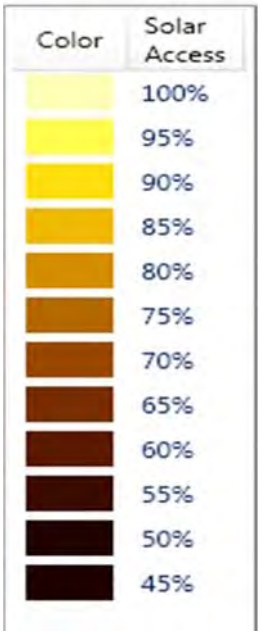
Month	Roof #1 AC (kWh)
Jan	1116.2
Feb	1512.7
Mar	2184.8
Apr	2638.4
May	3355.9
Jun	3338.6
Jul	3354.6
Aug	3068.9
Sep	2348.6
Oct	1838.7
Nov	1042.7
Dec	828.5
Annual	26628.8

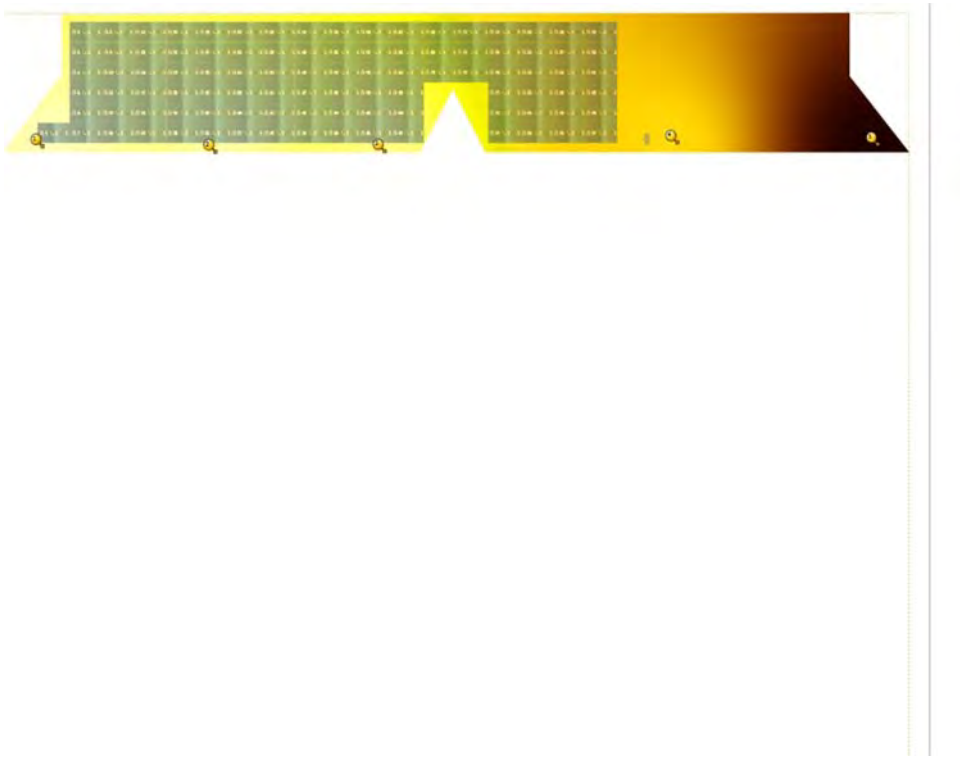
Design Result Chart:



Layout View:

Length: 152.03 ft
Width: 152.00 ft
Azimuth: 270.00 °
Slope: 18.00 °
Total Modules: 97





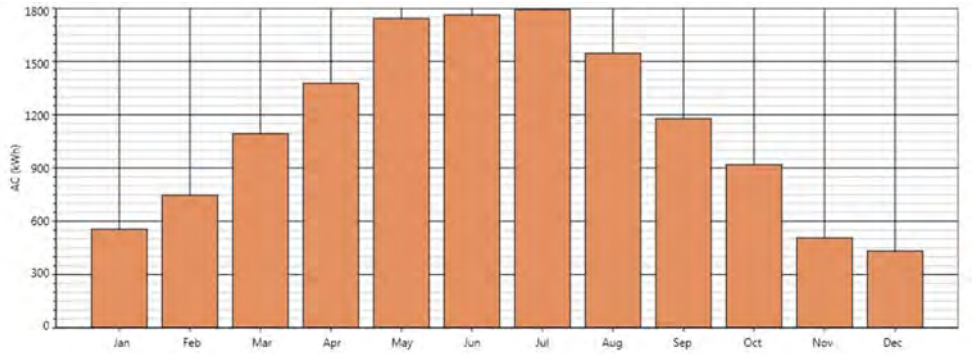
Roof #2 Design

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Custom
Inverter Model: Enphase Energy
(Due to spacing constraints, only the manufacturer and model of the first inverter is included in this report)
Derate Factor: 0.76

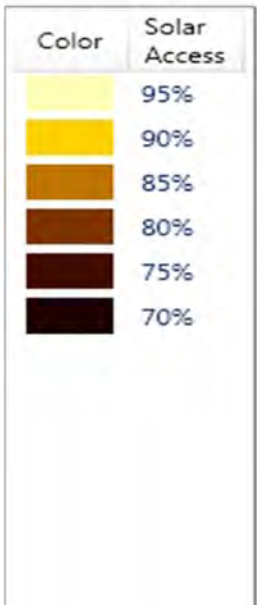
Month	Roof #2 AC (kWh)
Jan	558.4
Feb	749.3
Mar	1095.4
Apr	1379.6
May	1744.8
Jun	1765.1
Jul	1793.7
Aug	1548.0
Sep	1180.3
Oct	921.3
Nov	509.3
Dec	435.7
Annual	13680.8

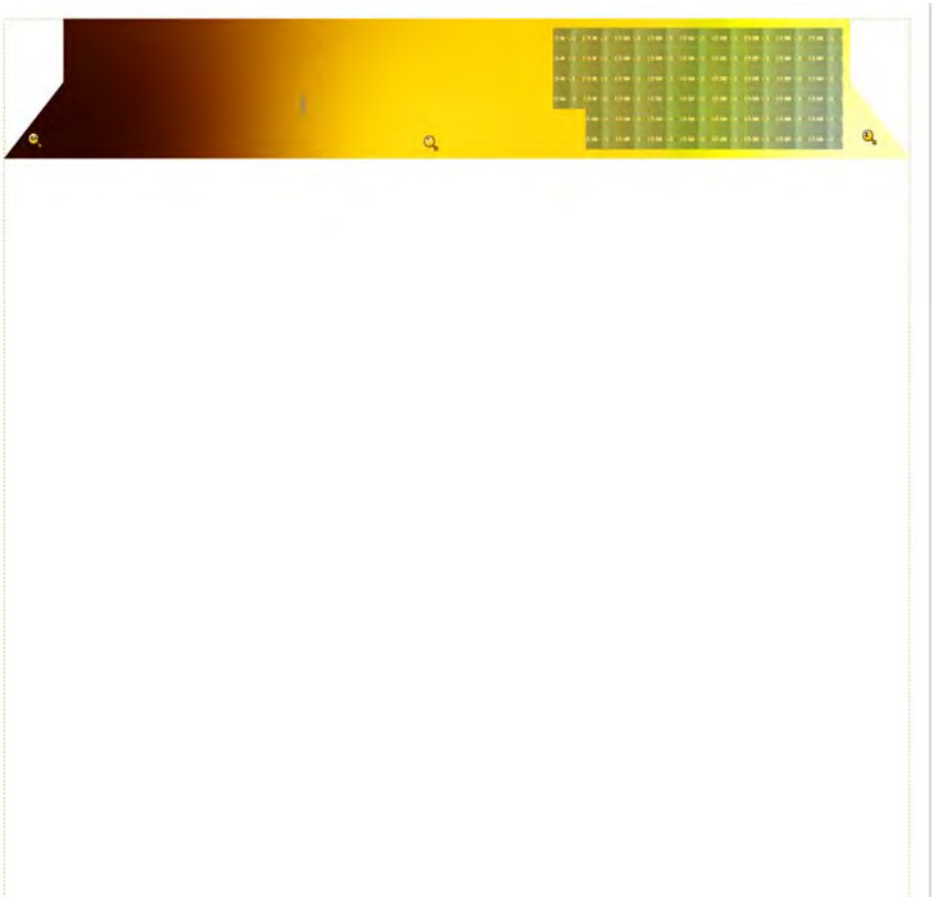
Design Result Chart:



Layout View:

Length: 152.03 ft
Width: 152.00 ft
Azimuth: 90.00 °
Slope: 18.00 °
Total Modules: 52



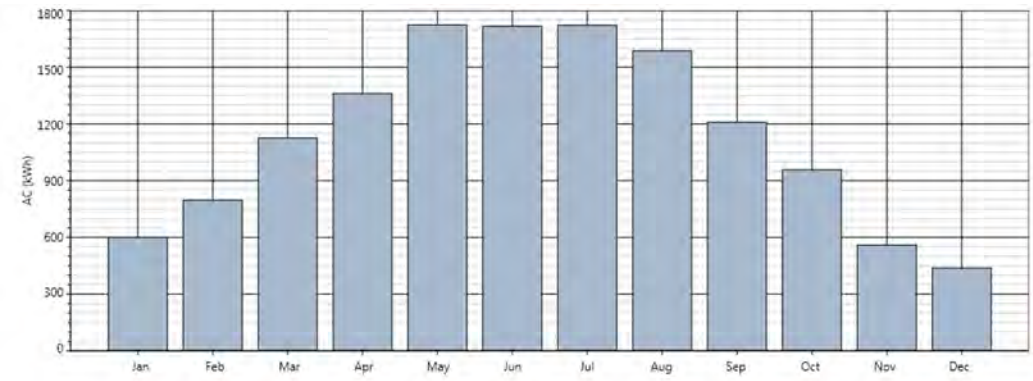


Roof #3 Design

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Custom
Inverter Model: Enphase Energy
(Due to spacing constraints, only the manufacturer and model of the first inverter is included in this report)
Derate Factor: 0.76

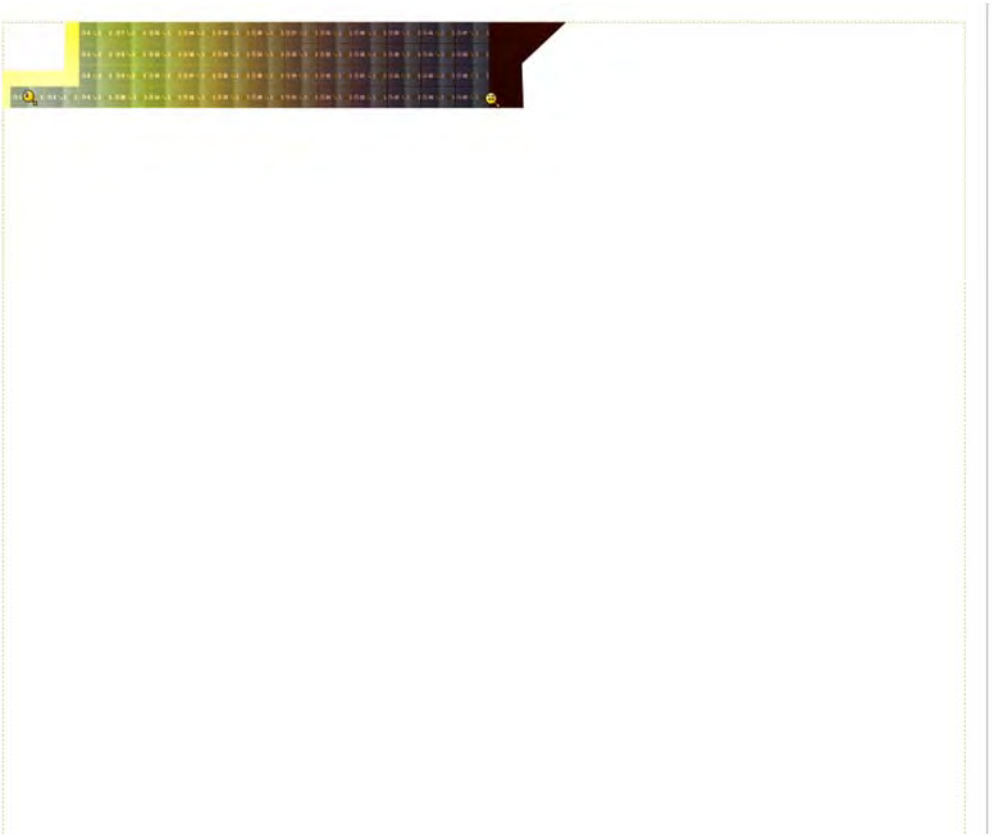
Design Result Chart:



Month	Roof #3 AC (kWh)
Jan	602.3
Feb	798.8
Mar	1128.8
Apr	1363.5
May	1726.1
Jun	1719.6
Jul	1724.9
Aug	1589.8
Sep	1211.6
Oct	960.4
Nov	562.0
Dec	441.2
Annual	13829.0

Layout View:

Length: 152.03 ft
Width: 152.00 ft
Azimuth: 270.00 °
Slope: 18.00 °
Total Modules: 50



Solmetric

Roof #4 Design

Design Properties:

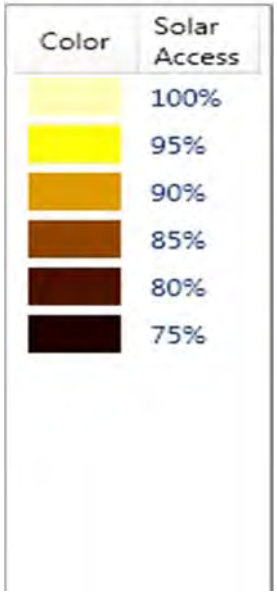
Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Custom
Inverter Model: Enphase Energy
(Due to spacing constraints, only the manufacturer and model of the first inverter is included in this report)
Derate Factor: 0.76

Month	Roof #4 AC (kWh)
Jan	423.4
Feb	577.4
Mar	829.8
Apr	992.3
May	1167.1
Jun	1180.1
Jul	1203.4
Aug	1059.8
Sep	894.7
Oct	661.9
Nov	414.9
Dec	355.3
Annual	9759.8

Design Result Chart:

Layout View:

Length: 143.00 ft
Width: 42.00 ft
Azimuth: 180.00 °
Slope: 10.00 °
Total Modules: 35



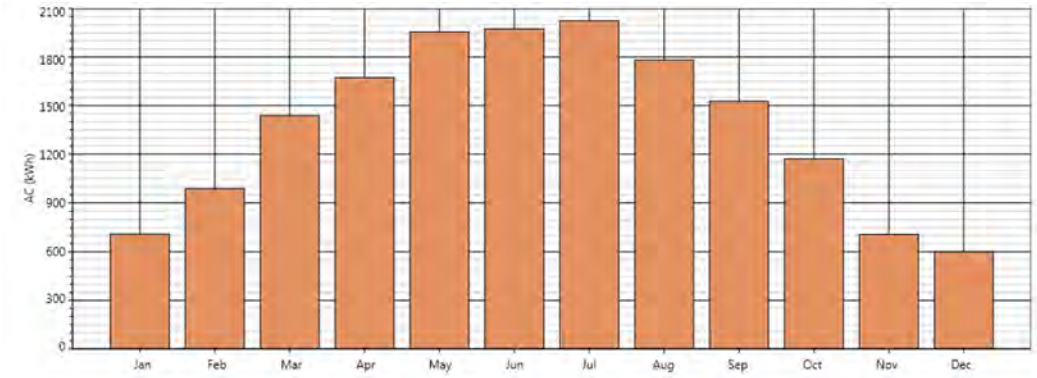
Roof #5 Design

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Custom
Inverter Model: Enphase Energy
(Due to spacing constraints, only the manufacturer and model of the first inverter is included in this report)
Derate Factor: 0.76

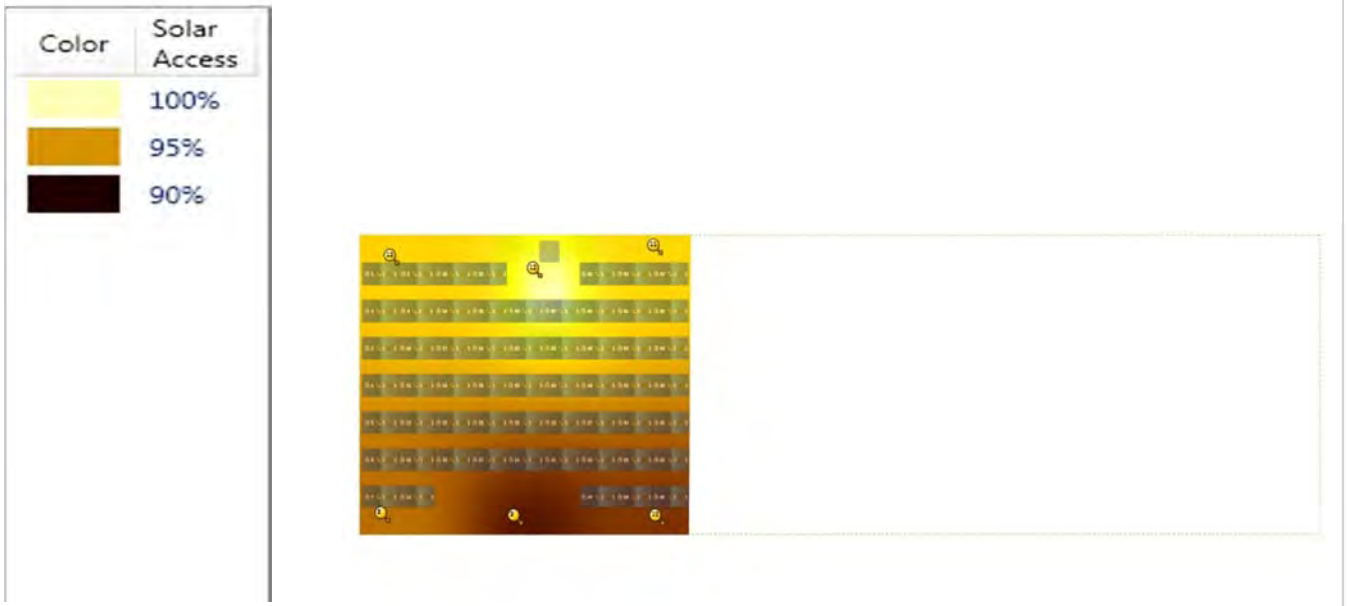
Month	Roof #5 AC (kWh)
Jan	712.7
Feb	989.8
Mar	1441.8
Apr	1676.4
May	1958.0
Jun	1977.5
Jul	2027.1
Aug	1784.4
Sep	1529.5
Oct	1173.9
Nov	710.4
Dec	603.0
Annual	16584.5

Design Result Chart:



Layout View:

Length: 143.00 ft
Width: 42.00 ft
Azimuth: 180.00 °
Slope: 10.00 °
Total Modules: 57



Solar Access and Shade Report – Roofs #1, #2 and #3

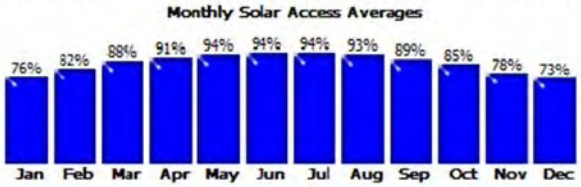
Session Properties

Name	terre haute
Creation Date	3/25/2014 10:37
Note	(none)
Location	39.5°N, 87.4°W Mag Dec: 3.6°W Time Zone: GMT-05:00

Solar access averages of 10 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06, Sky07, Sky08, Sky09, Sky10

Annual	May-Oct	Nov-Apr
89%	92%	84%

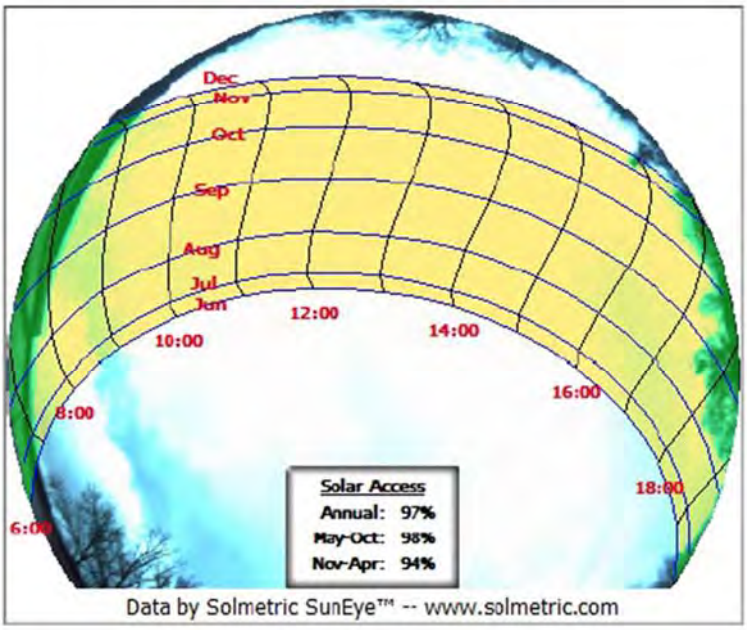


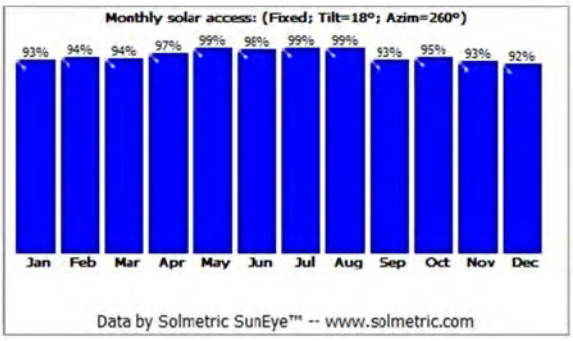
Skylines

- **Sky01 - (no skyline note)**
- **Sky02 - north west**
- **Sky03 - (no skyline note)**
- **Sky04 - (no skyline note)**
- **Sky05 - fruitridge ave side by tree**
- **Sky06 - (no skyline note)**
- **Sky07 - (no skyline note)**
- **Sky08 - (no skyline note)**
- **Sky09 - east bldg north**
- **Sky10 - (no skyline note)**

Sky01 -- 3/25/2014 10:46 -- (no skyline note)

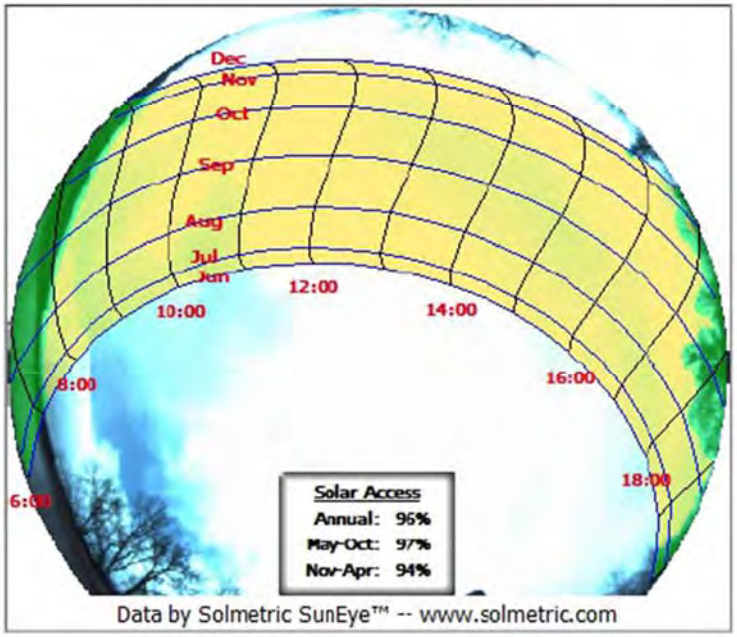
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=174°**
Solar Access: Annual: 97% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 94%

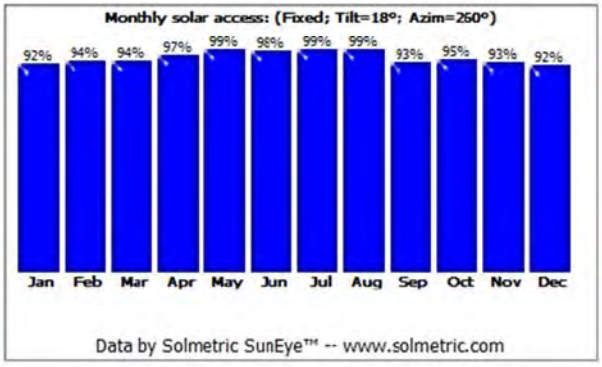



Monthly solar access: (Fixed; Tilt=18°; Azim=260°)
93% 94% 94% 97% 99% 98% 99% 99% 93% 95% 93% 92%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky02 -- 3/25/2014 10:48 -- north west

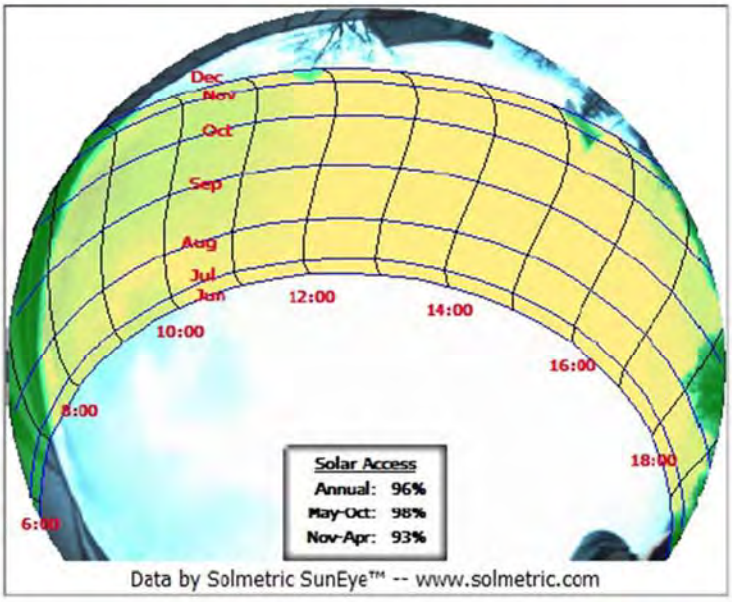
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=172°**
Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 94%

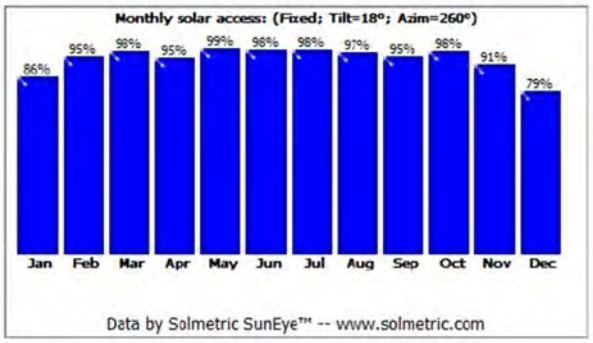



Monthly solar access: (Fixed; Tilt=18°; Azim=260°)
92% 94% 94% 97% 99% 98% 99% 99% 93% 95% 93% 92%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky03 -- 3/25/2014 10:51 -- (no skyline note)

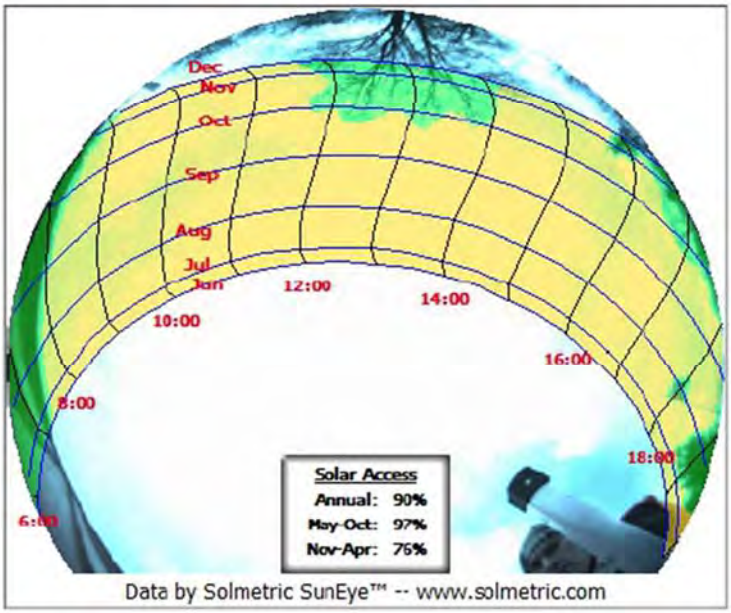
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=176°**
Solar Access: Annual: 96% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 93%

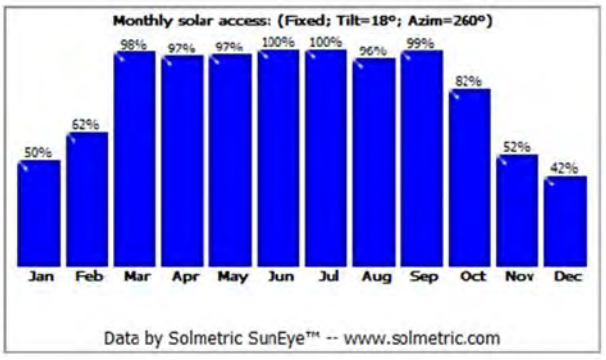




Sky04 -- 3/25/2014 10:56 -- (no skyline note)

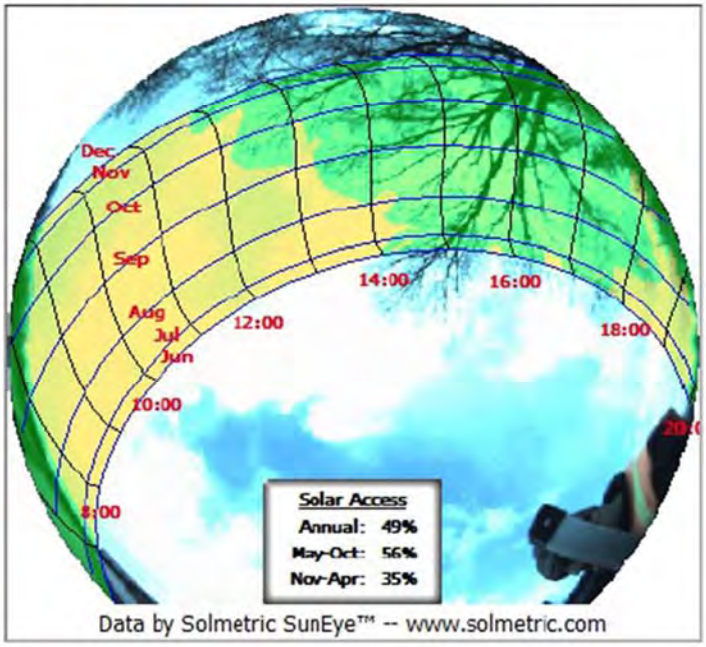
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=176°**
Solar Access: Annual: 90% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 76%

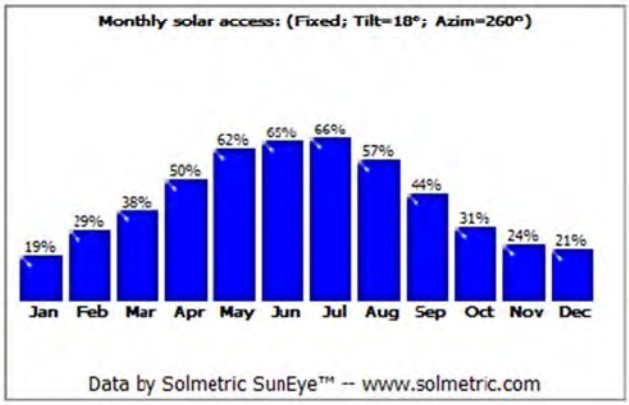




Sky05 -- 3/25/2014 10:58 -- fruitridge ave side by tree

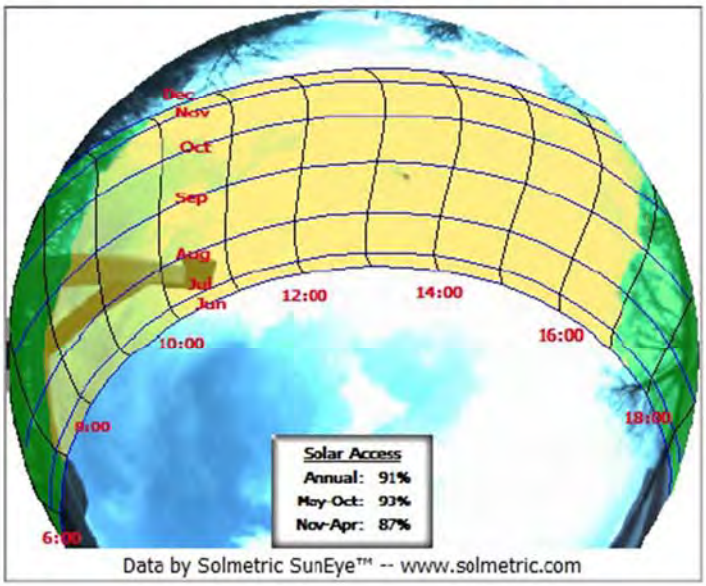
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=200°**
Solar Access: Annual: 49% -- Summer (May-Oct): 56% -- Winter (Nov-Apr): 35%

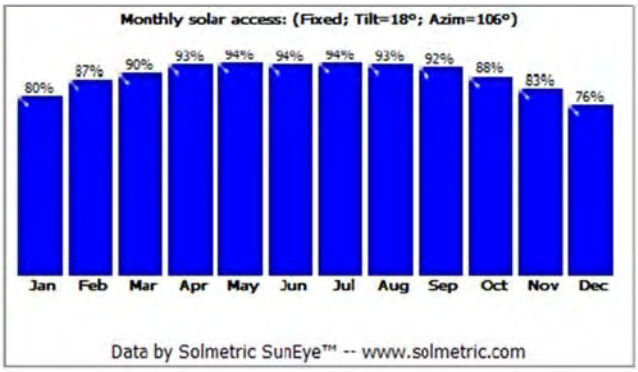




Sky06 -- 3/25/2014 11:08 -- (no skyline note)

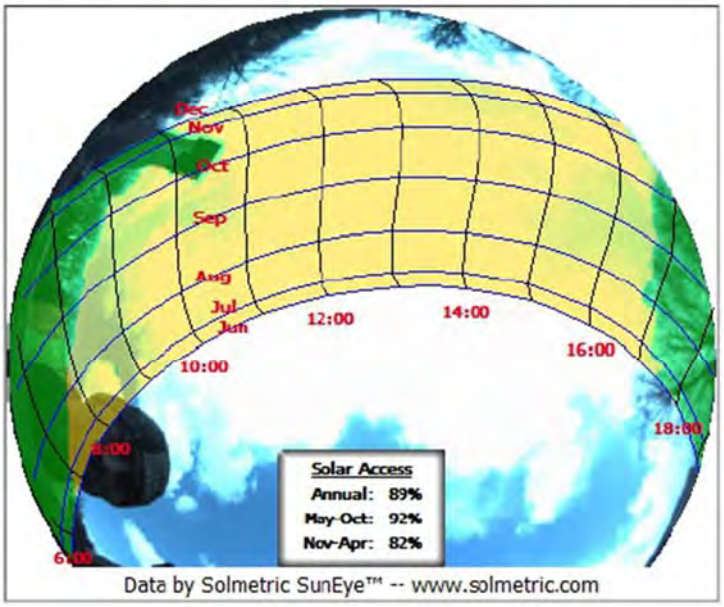
Panel Orientation: Tilt=18° -- Azimuth=106° -- **Skyline Heading=183°**
Solar Access: Annual: 91% -- Summer (May-Oct): 93% -- Winter (Nov-Apr): 87%

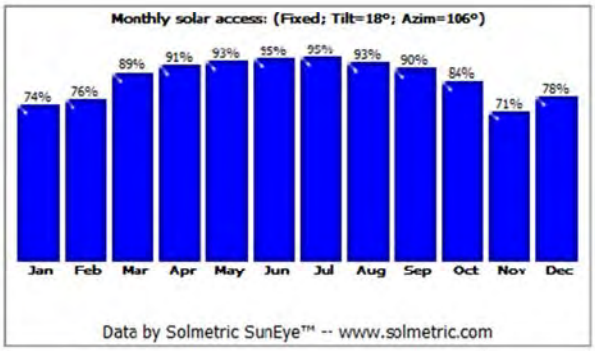




Sky07 -- 3/25/2014 11:11 -- (no skyline note)

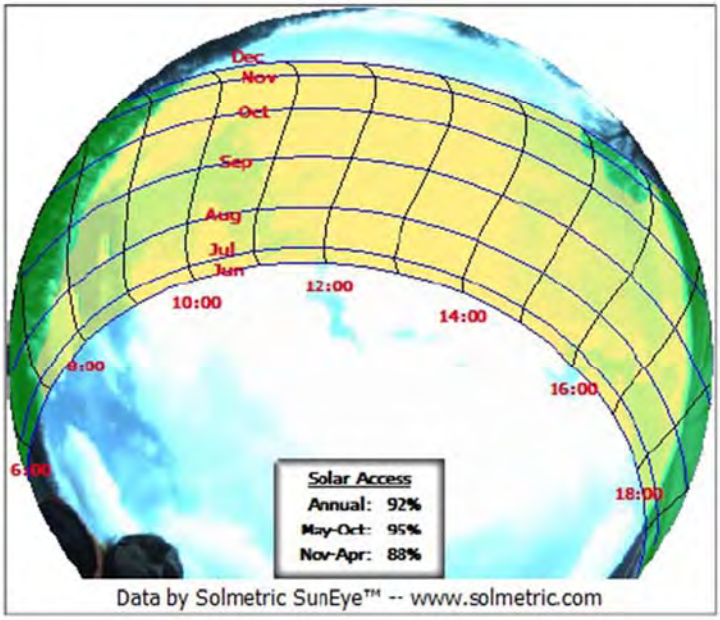
Panel Orientation: Tilt=18° -- Azimuth=106° -- **Skyline Heading=184°**
Solar Access: Annual: 89% -- Summer (May-Oct): 92% -- Winter (Nov-Apr): 82%

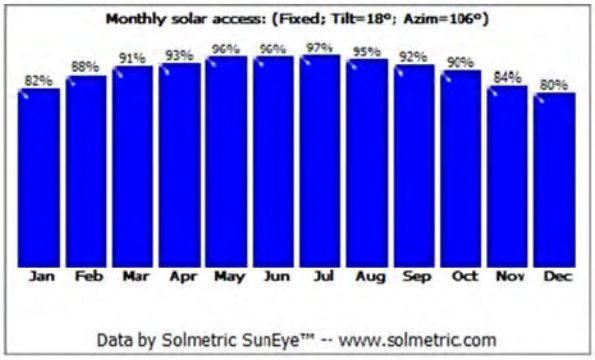




Sky08 -- 3/25/2014 11:16 -- (no skyline note)

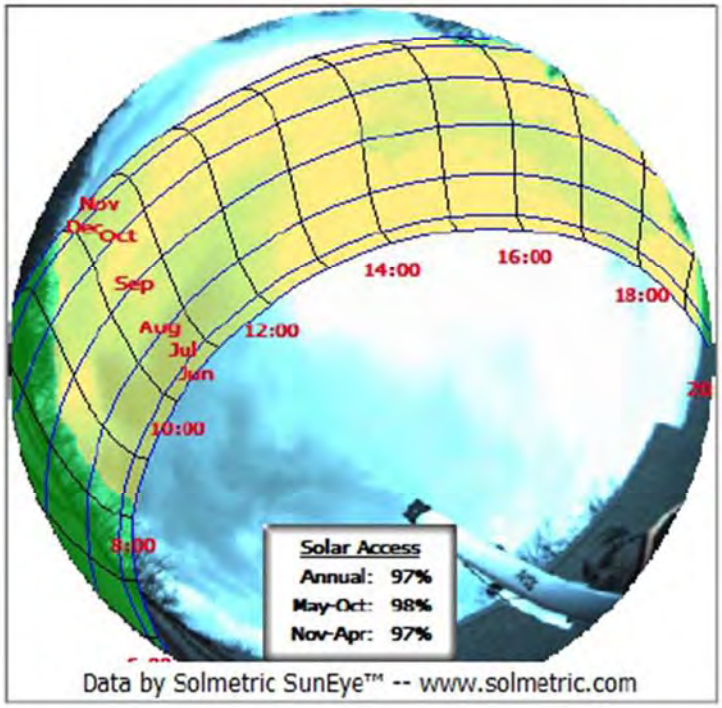
Panel Orientation: Tilt=18° -- Azimuth=106° -- **Skyline Heading=169°**
Solar Access: Annual: 92% -- Summer (May-Oct): 95% -- Winter (Nov-Apr): 88%

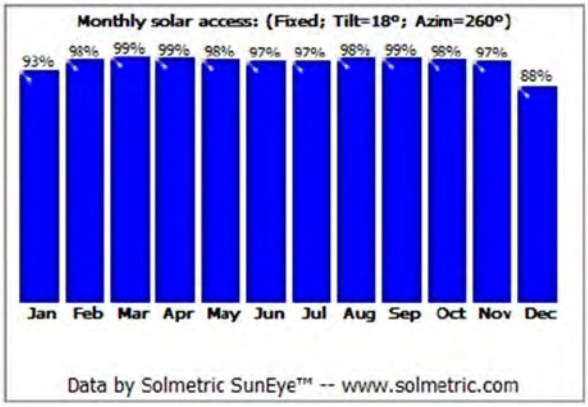




Sky09 -- 3/25/2014 11:20 -- east bldg north

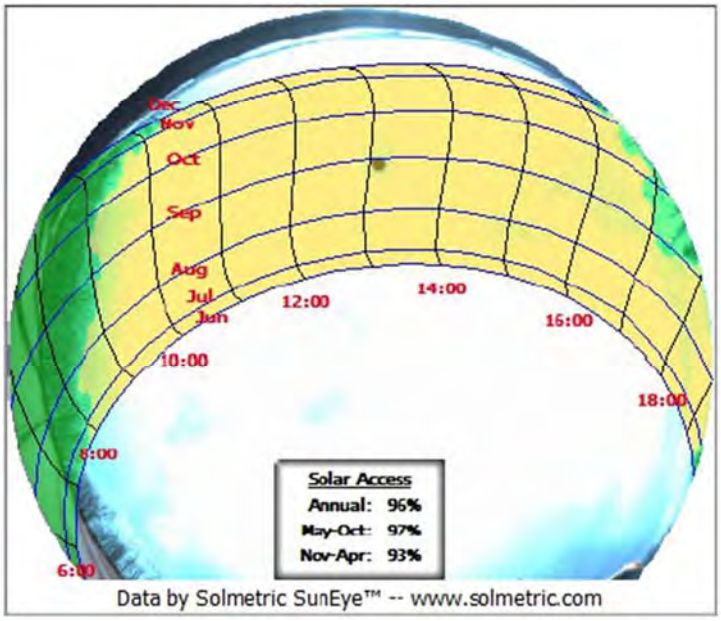
Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=208°**
Solar Access: Annual: 97% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 97%

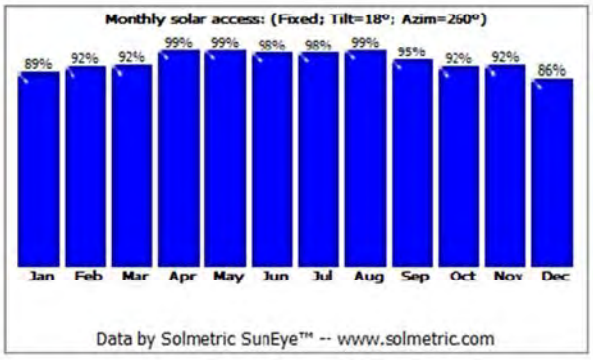



Monthly solar access: (Fixed; Tilt=18°; Azim=260°)
93% 98% 99% 99% 98% 97% 97% 98% 99% 98% 97% 88%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky10 -- 3/25/2014 11:25 -- (no skyline note)

Panel Orientation: Tilt=18° -- Azimuth=260° -- **Skyline Heading=187°**
Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 93%




Monthly solar access: (Fixed; Tilt=18°; Azim=260°)
89% 92% 92% 99% 99% 98% 98% 99% 95% 92% 92% 86%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Solar Access and Shade Report – Roofs #4 & #5

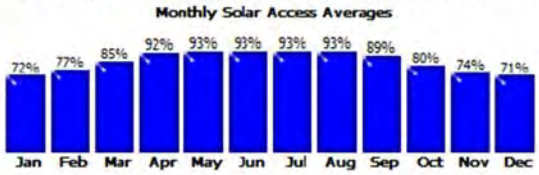
Session Properties

Name	terre haute flat roof
Creation Date	3/25/2014 11:38
Note	(none)
Location	39.5°N, 87.4°W Mag Dec: 3.6°W Time Zone: GMT-05:00

Solar access averages of 13 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06, Sky07, Sky08, Sky09, Sky10, Sky11, Sky12, Sky13

Annual	May-Oct	Nov-Apr
88%	91%	81%

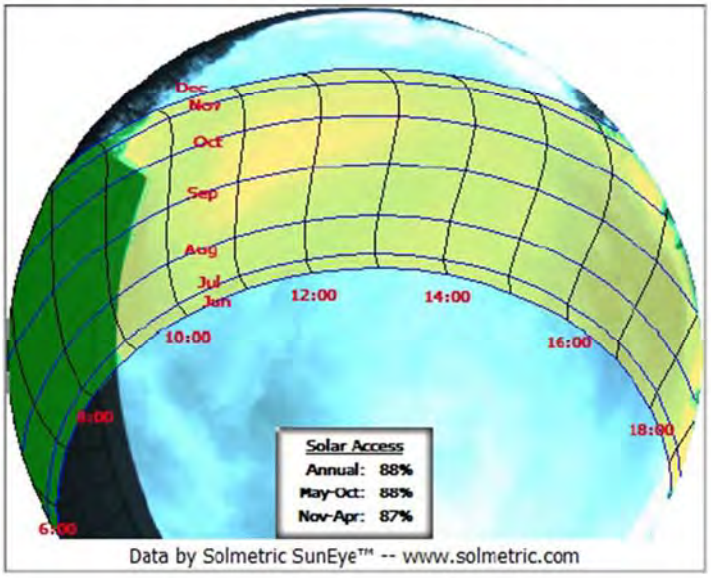


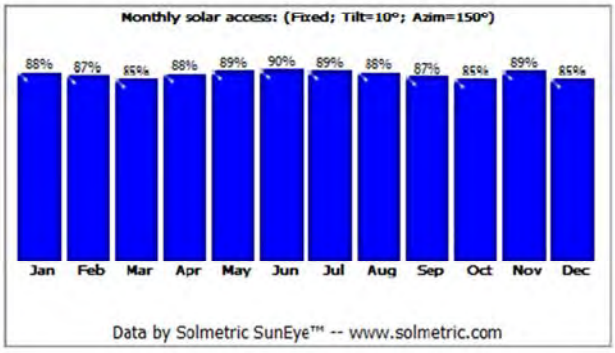
Skylines

- **Sky01 - (no skyline note)**
- **Sky02 - (no skyline note)**
- **Sky03 - (no skyline note)**
- **Sky04 - (no skyline note)**
- **Sky05 - (no skyline note)**
- **Sky06 - (no skyline note)**
- **Sky07 - (no skyline note)**
- **Sky08 - (no skyline note)**
- **Sky09 - (no skyline note)**
- **Sky10 - (no skyline note)**
- **Sky11 - (no skyline note)**
- **Sky12 - (no skyline note)**
- **Sky13 - (no skyline note)**

Sky01 -- 3/25/2014 11:42 -- (no skyline note)

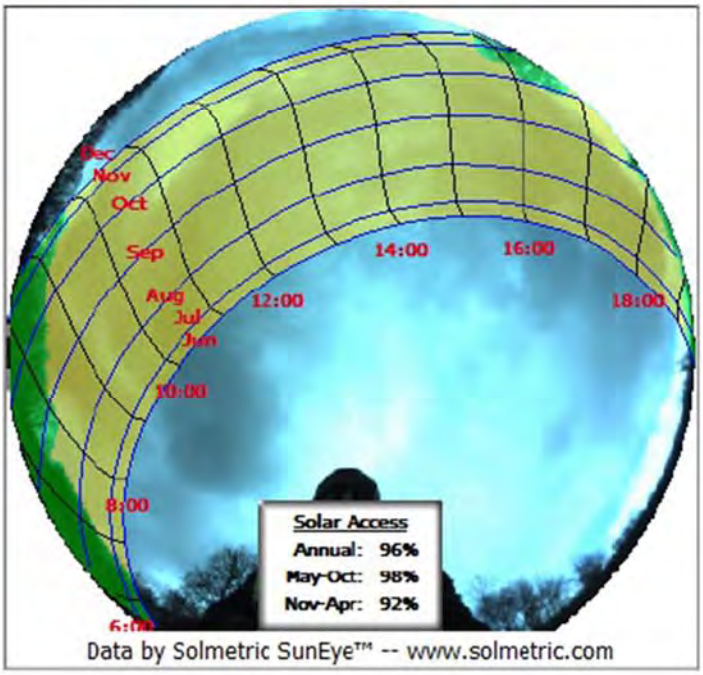
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=180°**
Solar Access: Annual: 88% -- Summer (May-Oct): 88% -- Winter (Nov-Apr): 87%

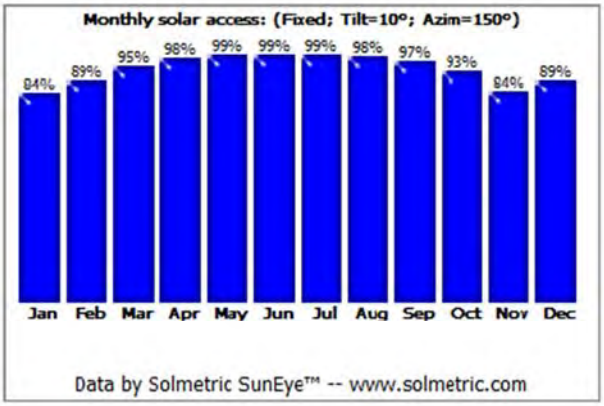



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
88% 87% 88% 88% 89% 90% 89% 88% 87% 88% 89% 88%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky02 -- 3/25/2014 11:43 -- (no skyline note)

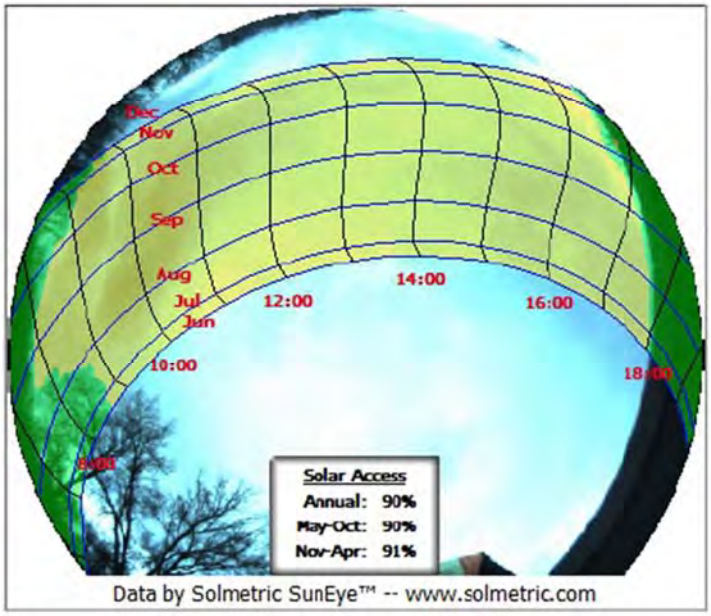
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=204°**
Solar Access: Annual: 96% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 92%

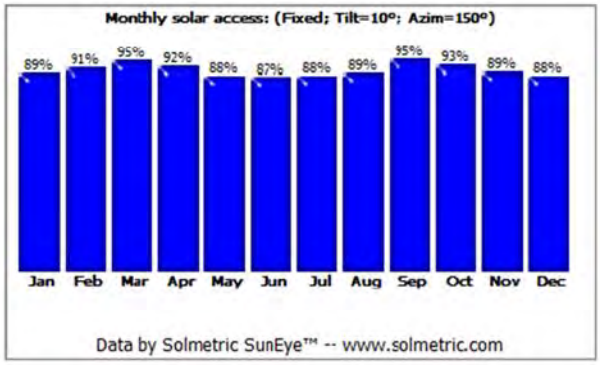



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
84% 89% 95% 98% 99% 99% 99% 98% 97% 93% 84% 89%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky03 -- 3/25/2014 11:44 -- (no skyline note)

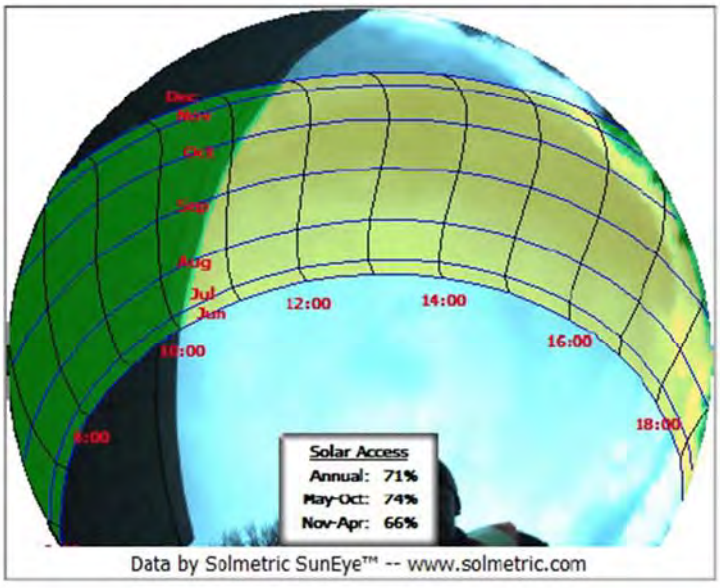
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=191°**
Solar Access: Annual: 90% -- Summer (May-Oct): 90% -- Winter (Nov-Apr): 91%

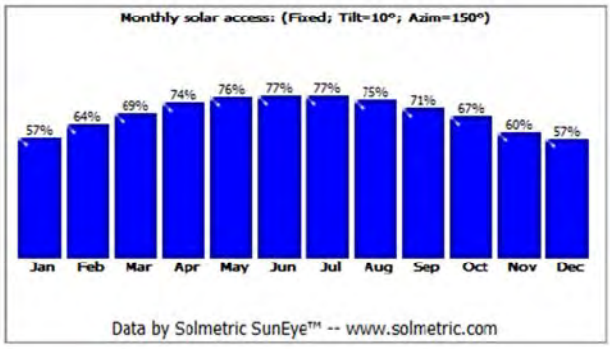



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
89% 91% 95% 92% 88% 87% 88% 89% 95% 93% 89% 88%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky04 -- 3/25/2014 11:45 -- (no skyline note)

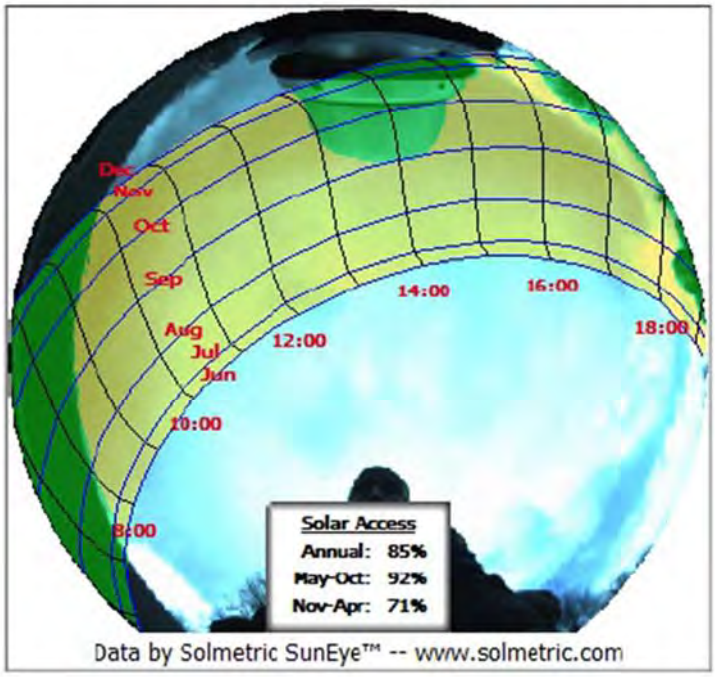
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=183°**
Solar Access: Annual: 71% -- Summer (May-Oct): 74% -- Winter (Nov-Apr): 66%

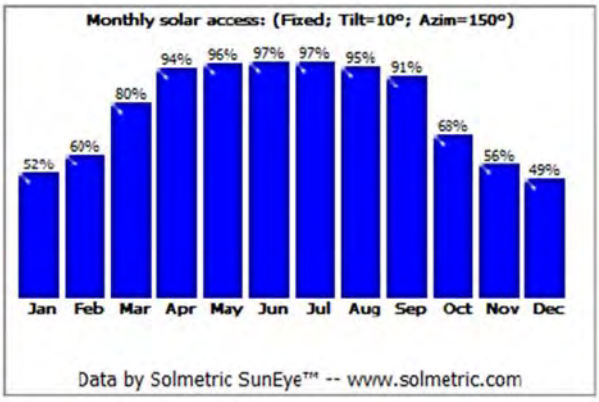



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
57% 64% 69% 74% 76% 77% 77% 75% 71% 67% 60% 57%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky05 -- 3/25/2014 11:45 -- (no skyline note)

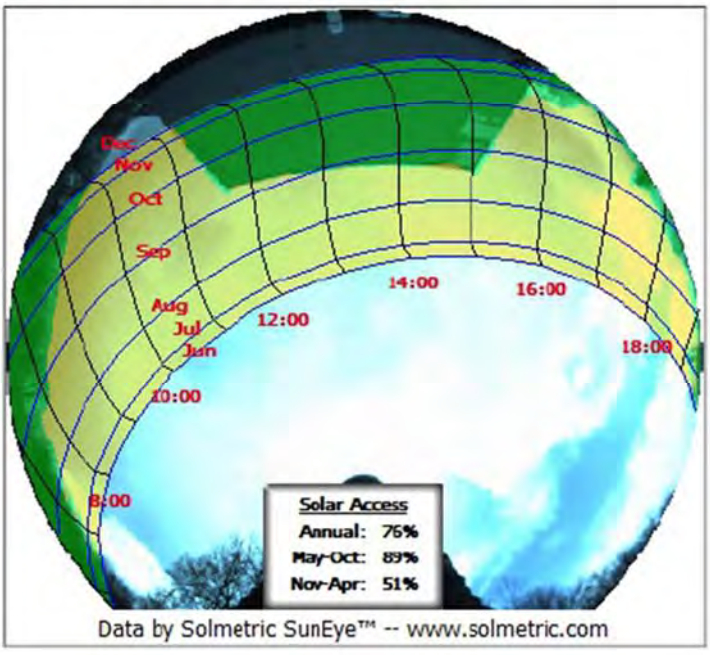
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=202°**
Solar Access: Annual: 85% -- Summer (May-Oct): 92% -- Winter (Nov-Apr): 71%

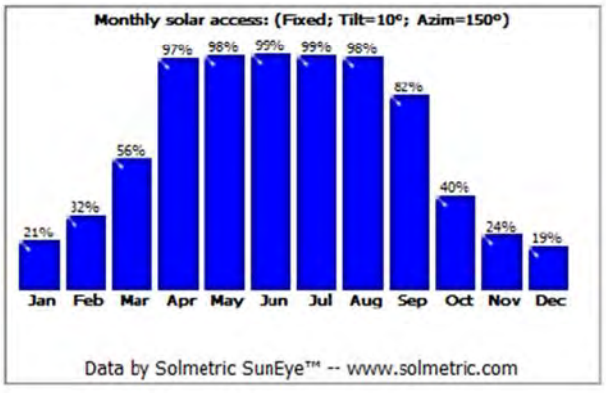




Sky06 -- 3/25/2014 11:46 -- (no skyline note)

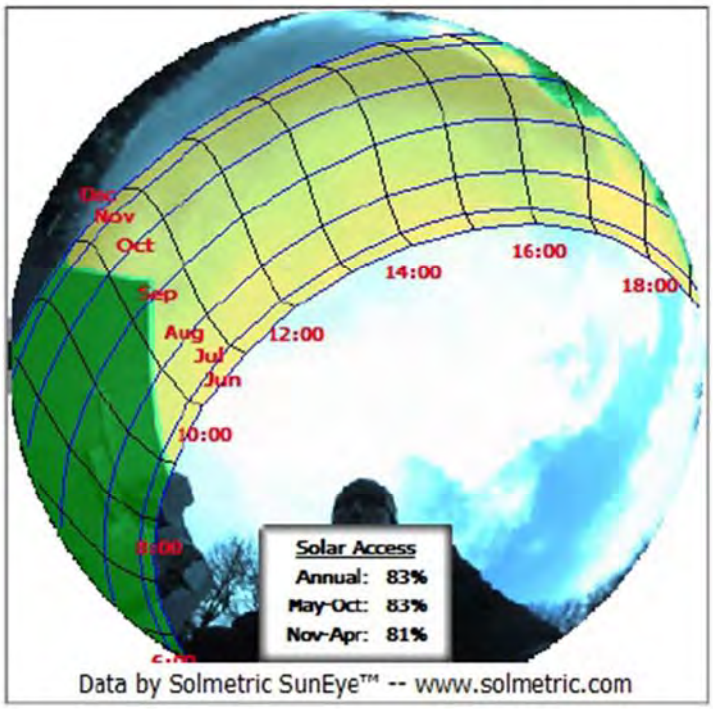
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=197°**
Solar Access: Annual: 76% -- Summer (May-Oct): 89% -- Winter (Nov-Apr): 51%

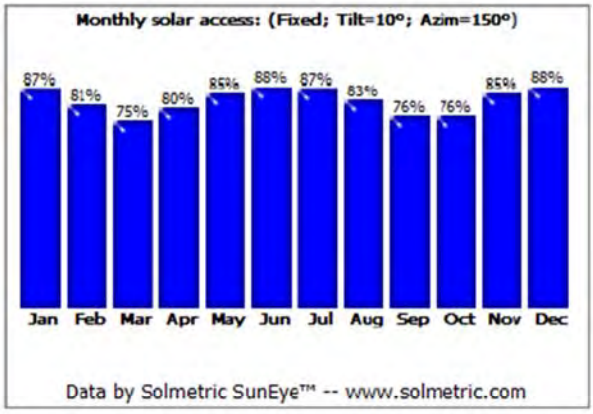




Sky07 -- 3/25/2014 11:47 -- (no skyline note)

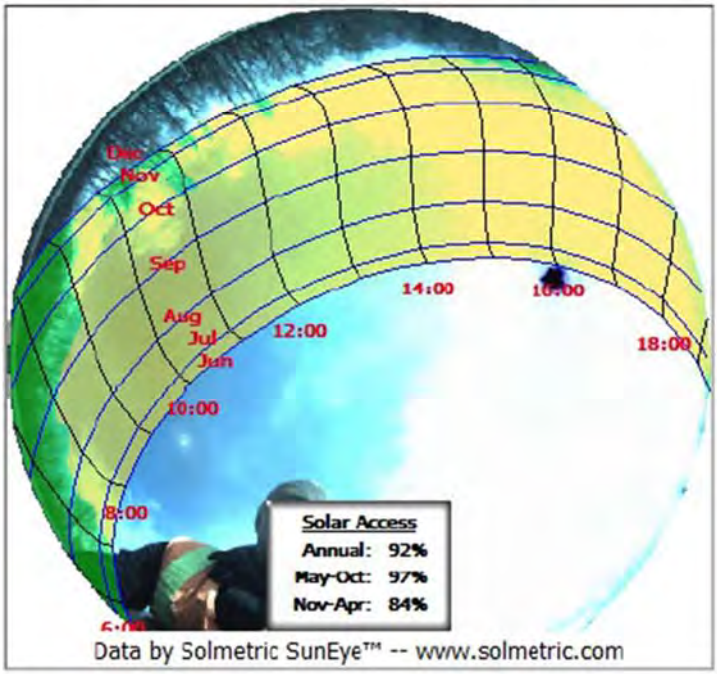
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=210°**
Solar Access: Annual: 83% -- Summer (May-Oct): 83% -- Winter (Nov-Apr): 81%

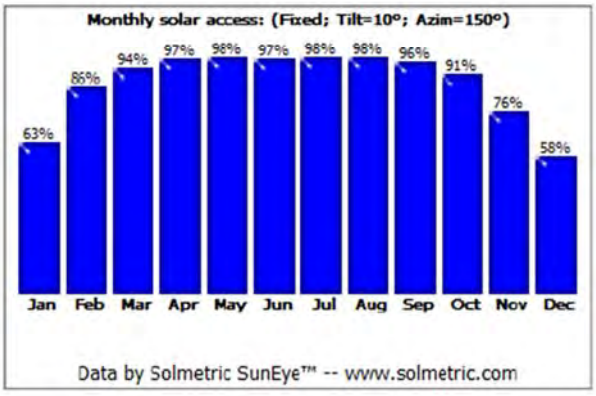




Sky08 -- 3/25/2014 11:52 -- (no skyline note)

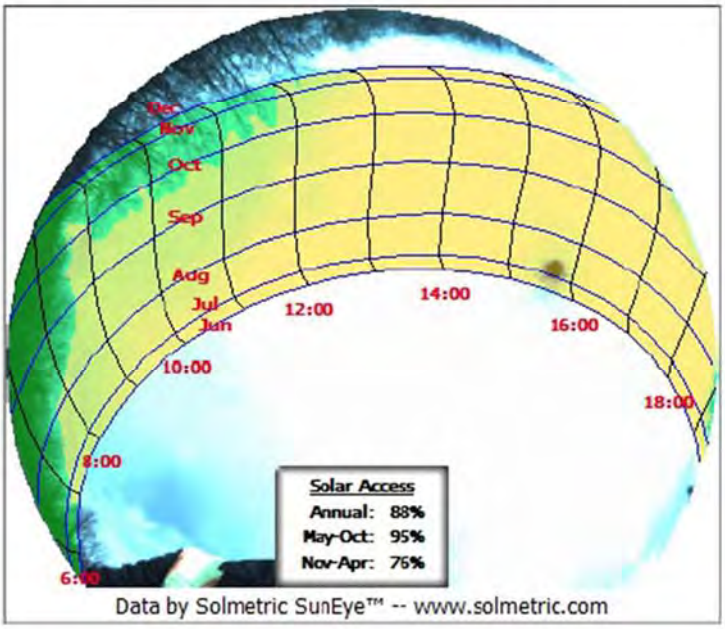
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=199°**
Solar Access: Annual: 92% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 84%

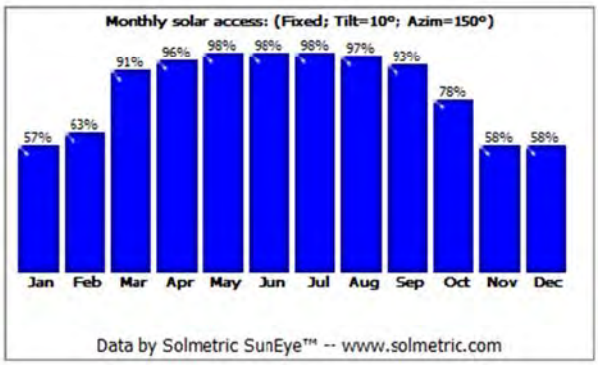




Sky09 -- 3/25/2014 11:54 -- (no skyline note)

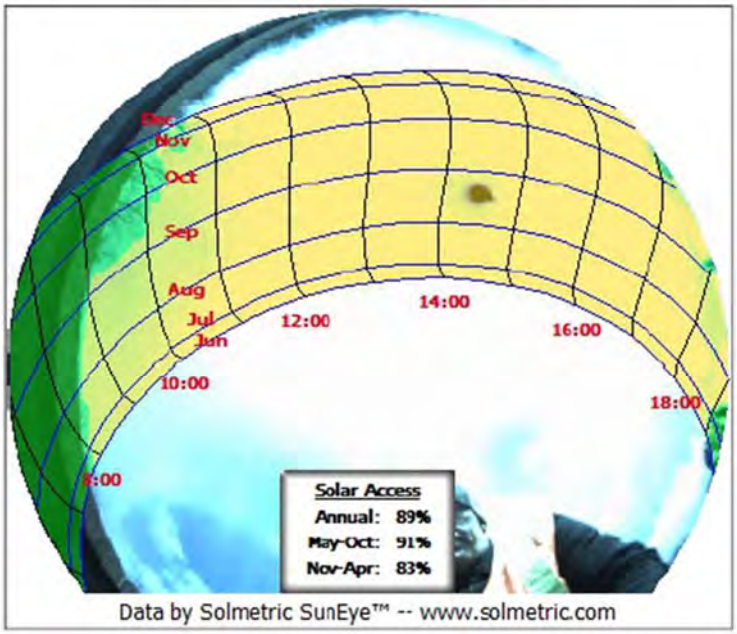
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=188°**
Solar Access: Annual: 88% -- Summer (May-Oct): 95% -- Winter (Nov-Apr): 76%

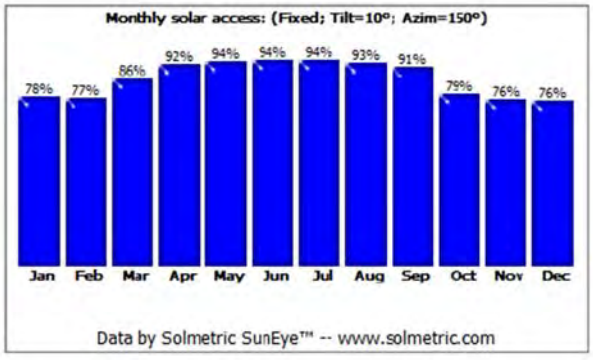




Sky10 -- 3/25/2014 11:55 -- (no skyline note)

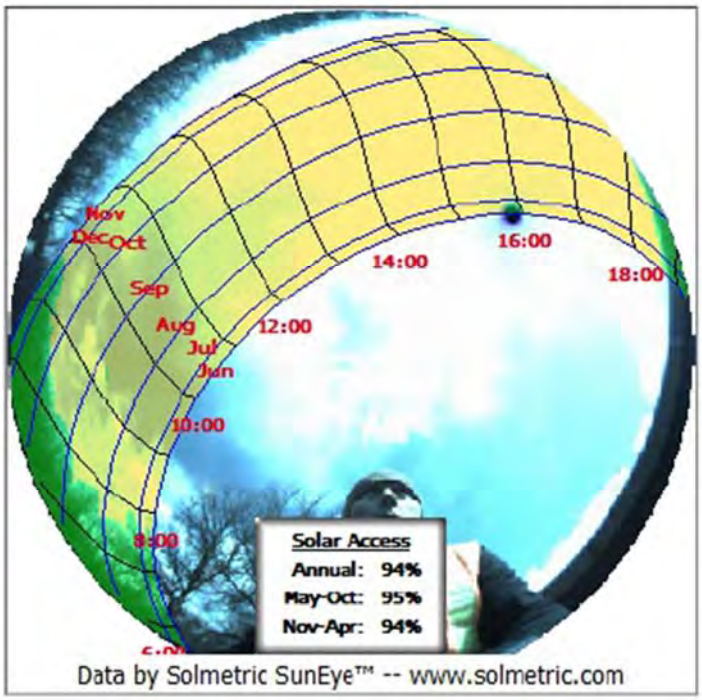
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=189°**
Solar Access: Annual: 89% -- Summer (May-Oct): 91% -- Winter (Nov-Apr): 83%

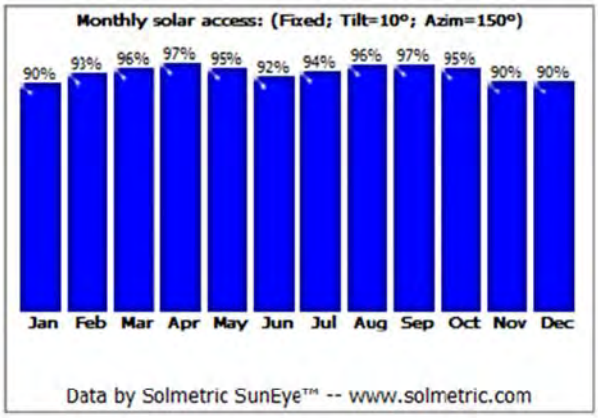




Sky11 -- 3/25/2014 11:57 -- (no skyline note)

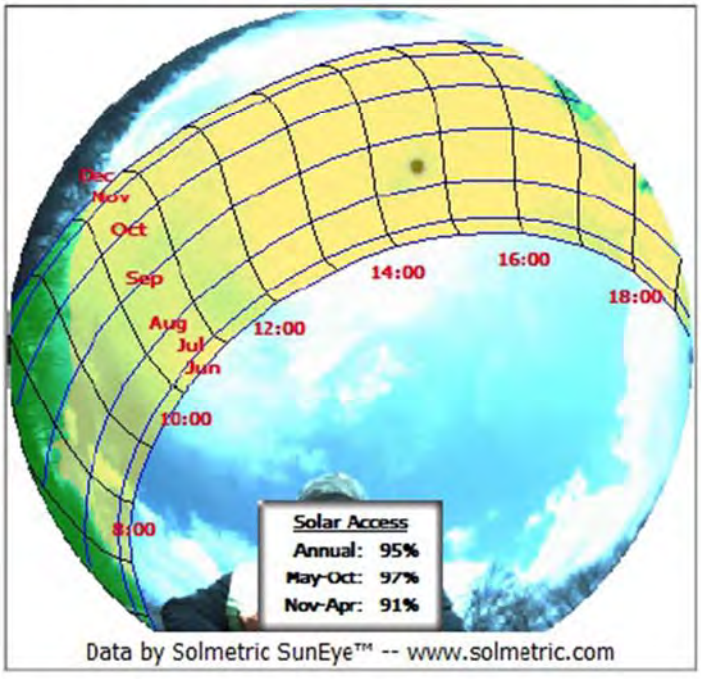
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=211°**
Solar Access: Annual: 94% -- Summer (May-Oct): 95% -- Winter (Nov-Apr): 94%

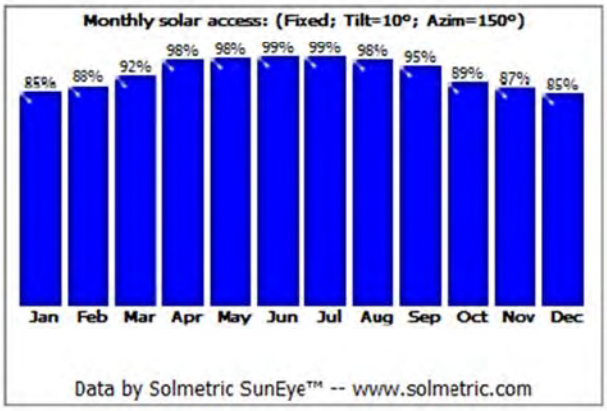



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
90% 93% 96% 97% 95% 92% 94% 96% 97% 95% 90% 90%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky12 -- 3/25/2014 11:58 -- (no skyline note)

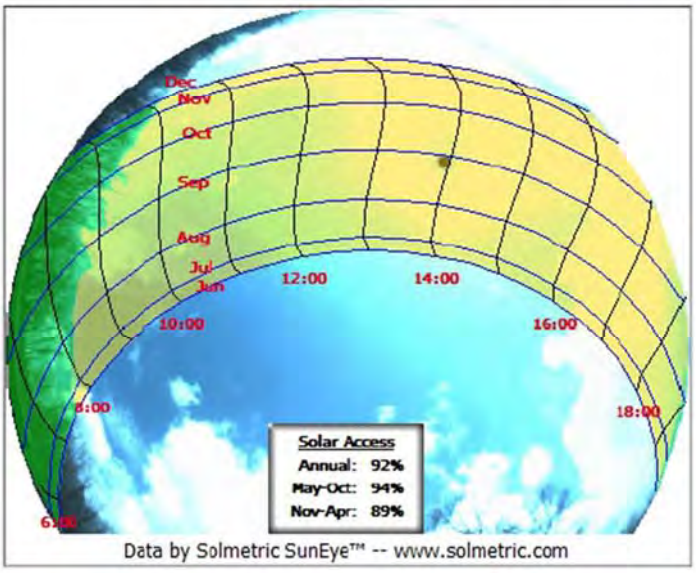
Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=206°**
Solar Access: Annual: 95% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 91%

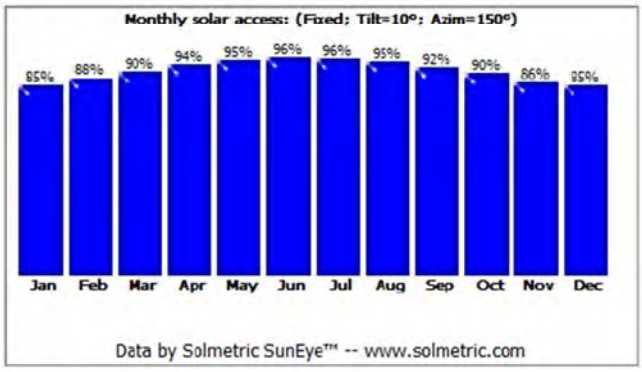



Monthly solar access: (Fixed; Tilt=10°; Azim=150°)
89% 88% 92% 98% 98% 99% 99% 98% 95% 89% 87% 85%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

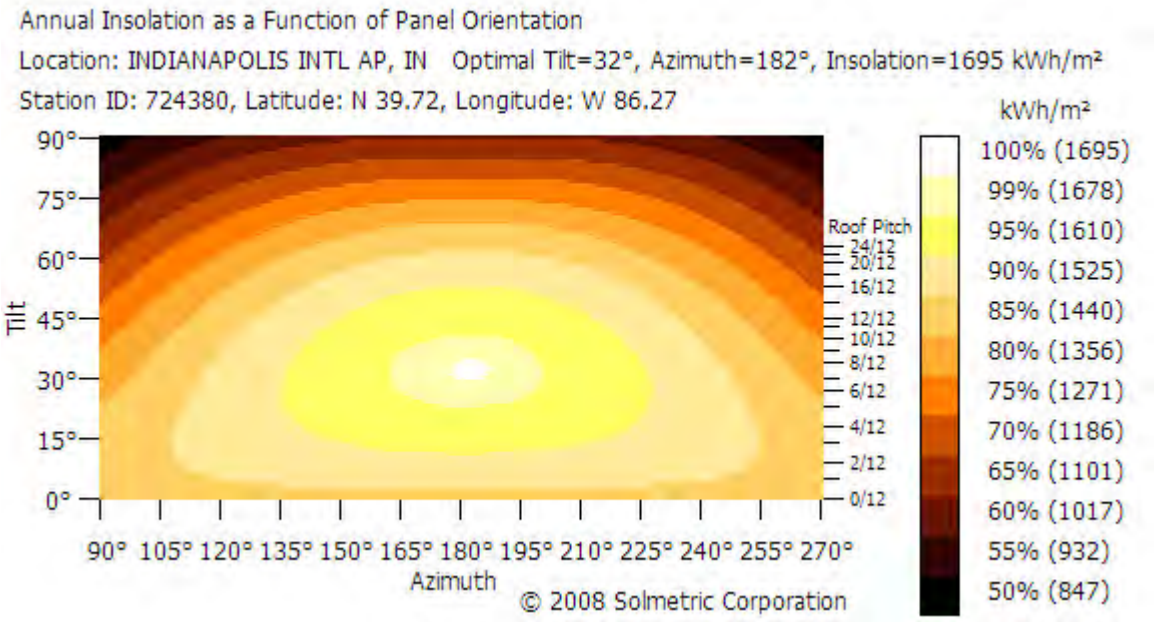
Sky13 -- 3/25/2014 12:00 -- (no skyline note)

Panel Orientation: Tilt=10° -- Azimuth=150° -- **Skyline Heading=181°**
Solar Access: Annual: 92% -- Summer (May-Oct): 94% -- Winter (Nov-Apr): 89%

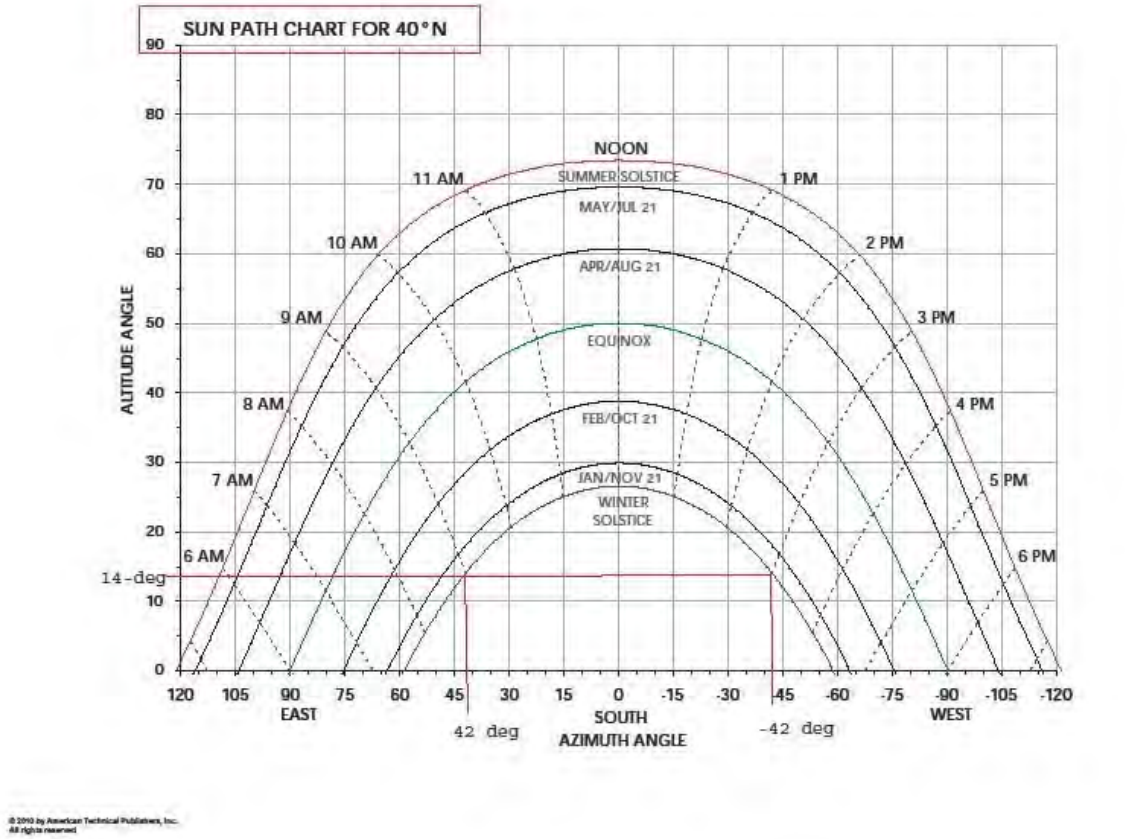




Supporting Data for PV Design in the Terre Haute Area



Annual Insolation data above indicates that a panel facing south will produce the highest kWH production facing 180° South for the Terre Haute/Indianapolis Area.



Solar Path for the Indianapolis Area. Red-line mark-ups were used to calculate PV panel spacing for flat roof application.

INDIANAPOLIS, IN (39.7°N, 86.3°W)

Elevation: 246 m Pressure: 988 mb

SOLAR RADIATION FOR FLAT-PLATE COLLECTORS FACING SOUTH AT A FIXED TILT*

Tilt		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0°	Average	2.0	2.8	3.7	4.9	5.9	6.5	6.3	5.6	4.6	3.3	2.1	1.6	**4.1**
	Minimum	1.6	2.3	3.2	4.1	5.1	5.9	5.6	5.0	4.0	2.8	1.7	1.3	**3.9**
	Maximum	2.3	3.3	4.1	5.7	6.9	7.7	7.0	6.4	5.2	3.8	2.5	2.0	**4.5**
Lat – 15°	Average	2.8	3.6	4.3	5.2	5.9	6.3	6.2	5.9	5.2	4.2	2.8	2.3	**4.6**
	Minimum	2.2	2.7	3.6	4.3	5.0	5.7	5.6	5.2	4.5	3.3	2.1	1.7	**4.4**
	Maximum	3.5	4.4	5.0	6.3	7.0	7.5	6.9	6.8	6.1	5.0	3.8	3.1	**5.1**
Lat°	Average	3.1	3.9	4.4	5.1	5.6	5.8	5.8	5.7	5.3	4.5	3.1	2.6	**4.6**
	Minimum	2.3	2.8	3.6	4.2	4.7	5.3	5.2	5.0	4.5	3.4	2.2	1.8	**4.3**
	Maximum	4.0	4.8	5.2	6.2	6.6	6.9	6.4	6.6	6.2	5.4	4.3	3.5	**5.1**
Lat + 15°	Average	3.3	4.0	4.3	4.7	4.9	5.0	5.1	5.2	5.1	4.5	3.2	2.7	**4.3**
	Minimum	2.4	2.8	3.5	3.9	4.2	4.6	4.5	4.6	4.3	3.4	2.2	1.9	**4.1**
	Maximum	4.3	5.0	5.1	5.7	5.8	5.9	5.6	5.9	5.9	5.4	4.5	3.8	**4.8**
90°	Average	3.0	3.5	3.2	3.0	2.7	2.6	2.7	3.1	3.5	3.6	2.8	2.5	**3.0**
	Minimum	2.1	2.4	2.5	2.5	2.4	2.4	2.5	2.7	2.9	2.6	1.8	1.6	**2.8**
	Maximum	4.1	4.6	3.8	3.6	3.1	2.8	2.9	3.5	4.1	4.4	4.1	3.7	**3.3**

SOLAR RADIATION FOR 1-AXIS TRACKING FLAT-PLATE COLLECTORS WITH A NORTH-SOUTH AXIS*

Axis Tilt		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0°	Average	2.7	3.7	4.7	6.2	7.5	8.2	8.1	7.4	6.1	4.5	2.7	2.1	**5.3**
	Minimum	2.0	2.8	3.8	4.9	6.1	7.2	6.9	6.4	5.1	3.4	1.9	1.5	**5.1**
	Maximum	3.4	4.6	5.7	7.9	9.1	10.4	9.2	8.9	7.2	5.4	3.8	2.8	**6.1**
Lat – 15°	Average	3.3	4.3	5.2	6.5	7.6	8.2	8.1	7.7	6.6	5.2	3.3	2.7	**5.7**
	Minimum	2.4	3.1	4.2	5.1	6.1	7.2	6.9	6.6	5.5	3.8	2.2	1.8	**5.4**
	Maximum	4.3	5.5	6.3	8.4	9.3	10.4	9.3	9.3	7.9	6.4	4.7	3.7	**6.6**
Lat°	Average	3.6	4.6	5.3	6.5	7.4	7.9	7.8	7.5	6.7	5.5	3.5	2.9	**5.8**
	Minimum	2.5	3.2	4.2	4.9	5.9	6.9	6.7	6.4	5.5	3.9	2.3	1.9	**5.4**
	Maximum	4.7	5.8	6.4	8.4	9.0	10.0	9.0	9.1	8.0	6.7	5.1	4.1	**6.6**
Lat + 15°	Average	3.7	4.7	5.2	6.2	6.9	7.3	7.3	7.1	6.5	5.5	3.6	3.0	**5.6**
	Minimum	2.6	3.2	4.1	4.7	5.6	6.4	6.2	6.1	5.3	3.9	2.4	2.0	**5.3**
	Maximum	4.9	5.9	6.4	8.1	8.5	9.3	8.4	8.7	7.8	6.7	5.3	4.3	**6.4**

SOLAR RADIATION FOR 2-AXIS TRACKING FLAT-PLATE COLLECTORS*

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
2-Axis Tracking	Average	3.7	4.7	5.3	6.6	7.7	8.4	8.3	7.7	6.7	5.5	3.6	3.1	**5.9**
	Minimum	2.6	3.2	4.2	5.1	6.2	7.3	7.1	6.6	5.6	4.0	2.4	2.0	**5.6**
	Maximum	4.9	5.9	6.5	8.5	9.4	10.6	9.5	9.4	8.1	6.7	5.3	4.4	**6.8**

DIRECT BEAM SOLAR RADIATION FOR CONCENTRATING COLLECTORS*

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1-Axis (E-W) Tracking	Average	2.0	2.3	2.3	2.8	3.4	3.7	3.7	3.4	3.1	2.9	1.9	1.6	**2.7**
	Minimum	1.1	1.1	1.4	1.7	2.2	3.0	2.7	2.6	2.3	1.6	0.9	0.8	**2.5**
	Maximum	3.0	3.4	3.2	4.2	4.8	5.8	4.8	4.7	4.3	3.8	3.3	2.7	**3.5**
1-Axis (N-S) Tracking, Tilt = 0°	Average	1.4	2.0	2.5	3.6	4.4	4.9	4.8	4.5	3.8	2.8	1.5	1.1	**3.1**
	Minimum	0.8	1.0	1.5	2.1	2.9	3.9	3.6	3.5	2.8	1.6	0.7	0.5	**2.8**
	Maximum	2.2	3.1	3.6	5.5	6.4	7.6	6.3	6.3	5.1	3.8	2.6	1.8	**4.0**
1-Axis (N-S) Tracking, Tilt = Lat°	Average	2.1	2.7	3.0	3.8	4.3	4.6	4.6	4.6	4.2	3.6	2.1	1.7	**3.4**
	Minimum	1.2	1.3	1.8	2.2	2.8	3.6	3.5	3.5	3.1	2.1	1.0	0.8	**3.1**
	Maximum	3.3	4.1	4.2	5.8	6.2	7.1	6.1	6.4	5.8	4.8	3.7	2.8	**4.4**
2-Axis Tracking	Average	2.3	2.8	3.0	3.9	4.6	5.0	5.0	4.7	4.2	3.6	2.2	1.8	**3.6**
	Minimum	1.3	1.4	1.9	2.3	3.0	4.0	3.7	3.6	3.2	2.1	1.1	0.9	**3.2**
	Maximum	3.5	4.2	4.2	5.9	6.6	7.8	6.5	6.7	5.8	4.8	3.9	3.0	**4.6**

AVERAGE CLIMATIC CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Temperature (°C)	-3.6	-1.3	5.2	11.3	17.1	22.2	24.1	22.9	19.2	12.6	6.1	-0.6	**11.3**
Average Low (°C)	-8.2	-6.2	-0.1	5.3	10.9	16.1	18.4	17.1	13.1	6.4	1.2	-4.9	**5.8**
Average High (°C)	0.9	3.5	10.5	17.4	23.2	28.2	29.7	28.7	25.3	18.8	11.1	3.6	**16.7**
Record Low (°C)	-30.0	-29.4	-21.7	-8.9	-2.2	3.9	6.7	5.0	-2.2	-8.3	-18.9	-30.6	**-30.6**
Record High (°C)	21.7	23.3	29.4	31.7	33.9	38.9	40.0	38.9	37.8	32.2	27.2	23.3	**40.0**
Heating Degree Days†	681	551	407	210	92	3	0	3	32	188	367	587	**3119**
Cooling Degree Days†	0	0	0	0	53	118	179	144	59	10	0	0	**563**
Relative Humidity (%)	75	74	70	66	67	68	73	75	74	72	76	78	**72**
Wind Speed (m/s)	4.7	4.6	5.1	4.7	4.1	3.7	3.3	3.1	3.4	3.8	4.4	4.6	**4.1**

* in kWh/m²/day, ±9%
† based on 18.3°C (65°F)

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Appendix A

PV Module Space Calculation

Flat Roof

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Engineering Calculation Sheet

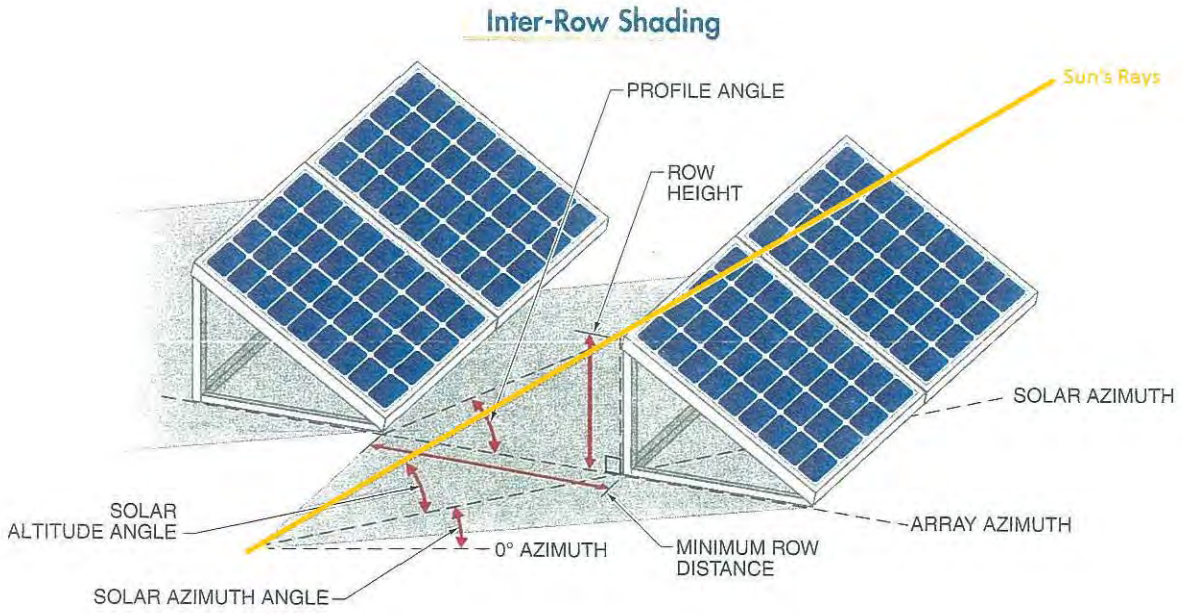
Date: 04/25/2014 By: ROT
Contract: 62018326
Calculation No.: 8326-Terre Haute

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Terre Haute, Indiana

The purpose of this calculation is to determine the minimum distance separation between modules when placed in rows for flat roof applications. Treating a row as a shading obstruction to the row behind it, the following formula will calculate the minimum distance between rows to avoid shading.

$$d = p \times (\cos(\psi-\mu)/\tan\alpha)$$

Where
d=minimum row separation distance (in ft)
p=row height (in)
ψ=azimuth angle per time of day (in deg)
α=solar altitude angle (in deg)
μ=PV module azimuth from south reference (in deg)



The rows must be spaced to avoid shading between 9AM and 3PM during the winter solstice. The orientation of the module out side of azimuth south, will impact the module spacing. The array azimuth and solar south azimuth will need to be added for both time references to determine worst case scenario for panel spacing,

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Contract: 62018326
Calculation No.: 8326-Terre Haute

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Terre Haute, Indiana

Calculate Panel Height on flat roof

Solarworld Panel Module dimensions 39.41" x 65.94"

$\theta := 10deg$ Tilt Angle (in deg)

$h := 39.41in$ Tilt Length of PV module (h)

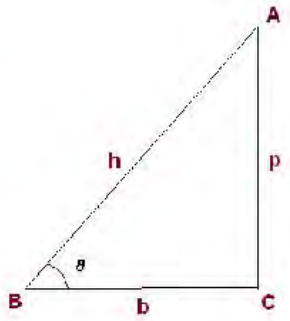
$p := h \cdot \sin(\theta)$ Panel Height from top of roof

$p = 6.84 \cdot in$

$\sin A = p / h$

$\cos \theta = b / h$

$\tan A = p / b$



Calculate Solar Azimuth and Solar Altitude from Sun Path Chart

The 40-deg N Sun path indicates the Solar Altitude Angle is 18-deg at 9:00AM and 3:00PM. The South azimuth angle is 42-deg and 9:00 AM and -42-deg and 3:00 PM.

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Engineering Calculation Sheet

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Subject
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PV Module Row Space Calculation
Terre Haute, Indiana

d= p x (cos(ψ-μ)/tanα)

Where
d=minimum row separation distance (in ft)
p=row height (in)
ψ=azimuth angle per time of day (9:00am) & (3:PM) (in deg)
α=solar altitude angle (in deg)
μ=PV module azimuth from due south (in deg)

$\psi_{.9am} := 42deg$ Azimuth angle of the sun from due South at 9:00 AM

$\psi_{3pm} := -42deg$ Azimuth angle of the sun from due South at 3:00 PM

$p = 6.84 \cdot in$

$\mu := 0deg$

$\alpha := 14deg$

$$d_{9am} := p \cdot \frac{\cos(\psi_{.9am} + \mu)}{\tan(\alpha)}$$

$d_{9am} = 20.40 \cdot in$

$$d_{3pm} := p \cdot \frac{\cos(\psi_{3pm} + \mu)}{\tan(\alpha)}$$

$d_{3pm} = 20.40 \cdot in$

$d_{max} := \max(d_{9am}, d_{3pm})$

$d_{max} = 20.40 \cdot in$ Worst case distance

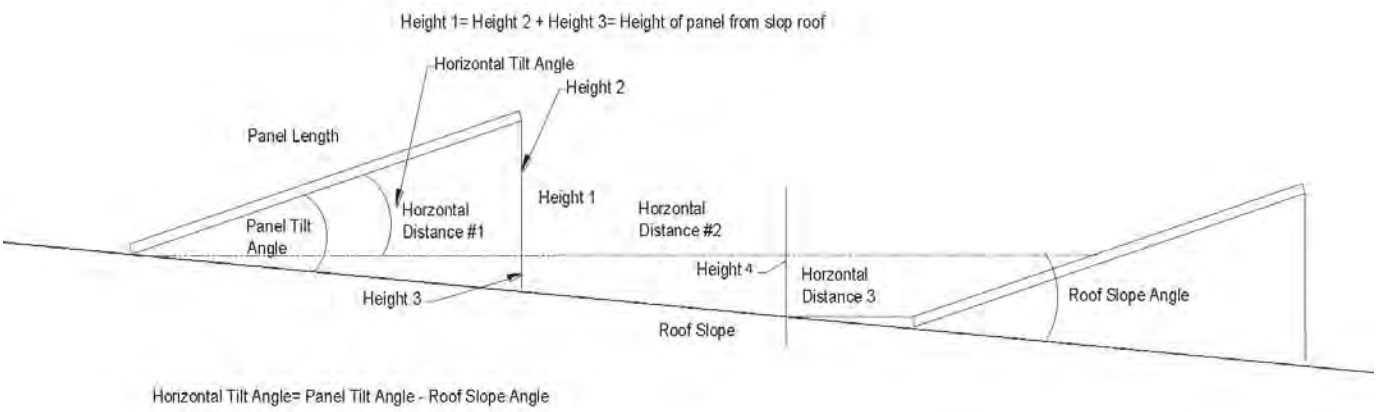
MERRICK® BUILDING QUALITY SOLUTIONS

Engineering Calculation Sheet

Date: 04/25/2014 By: ROT
Contract: 62018326
Calculation No.: 8326-Terre Haute

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Terre Haute, Indiana

The following calculation is to provide an adjustment to panel distances if there is a slight slope to the roof system



$\theta = 10.00 \cdot deg$ Panel Tilt Angle (in deg)

$\tau := 2.5deg$ Roof Slope Angle (in deg)

$\beta := \theta - \tau$ Horizontal Tilt Angle (in deg)

$\beta = 7.50 \cdot deg$

$h = 39.41 \cdot in$ Panel Length

$\psi_{9am} := 42deg$ Azimuth angle of the sun from due South at 9:00 AM

$\psi_{.3pm} := -42deg$ Azimuth angle of the sun from due South at 3:00 PM

$Distance_1 := h \cdot \cos(\beta)$ Horizontal Distance #1

$Distance_1 = 39.07 \cdot in$

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Terre Haute, Indiana

$Height_1 := h \cdot \sin(\theta)$

$Height_1 = 6.84 \cdot in$

$Height_2 := h \cdot \sin(\beta)$

$Height_2 = 5.14 \cdot in$

Distance #2 is calculated based on worst-case scenario from south Azimuth

$\mu = 0.00 \cdot deg$

$\alpha = 14.00 \cdot deg$

$\psi_{..9am} := 42deg$ Azimuth angle of the sun from due South at 9:00 AM

$\psi_{..3pm} := -42deg$ Azimuth angle of the sun from due South at 3:00 PM

$$distance_{2.9am} := Height_2 \cdot \frac{\cos(\psi_{..9am} + \mu)}{\tan(\alpha)}$$

$distance_{2.9am} = 15.33 \cdot in$ Distance #2 at 9:00am

$$distance_{2.3pm} := Height_2 \cdot \frac{\cos(\psi_{3pm} + \mu)}{\tan(\alpha)}$$

$distance_{2.3pm} = 15.33 \cdot in$ Distance #2 at 3:00pm

$d_{max} := \max(distance_{2.9am}, distance_{2.3pm})$

$d_{max} = 15.33 \cdot in$

Worst case distance for Distance 2

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Engineering Calculation Sheet

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Contract: 62018326
Calculation No.: 8326-Terre Haute

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Terre Haute, Indiana

$$height_4 := \left(distance_{2.3pm} + Distance_1\right)\cdot\tan(\tau)$$

$$height_4 = 2.38\cdot in$$

$$distance_{3.9am} := height_4\cdot\frac{\cos\left(\psi_{.9am} + \mu\right)}{\tan(\alpha)}$$

$$distance_{3.9am} = 7.08\cdot in$$ Distance #2 at 9:00am

$$distance_{3.3pm} := height_4\cdot\frac{\cos\left(\psi_{3pm} + \mu\right)}{\tan(\alpha)}$$

$$distance_{3.3pm} = 7.08\cdot in$$ Distance #2 at 3:00pm

$$d_{.max} := \max\left(distance_{3.9am}, distance_{3.3pm}\right)$$

$$d_{.max} = 7.08\cdot in$$ Worst case distance for Distance 2

Total Maximum distance due to roof slope = Distance #2 + Distance#1

Total Distance= $distance_{3.9am} + distance_{2.9am} = 22.41\cdot in$

Appendix B

Catalog Cut Sheets

Sunmodule® Plus SW 275 mono

TUV Power controlled:
Lowest measuring tolerance in industry

Every component is tested to meet
3 times IEC requirements

Designed to withstand heavy
accumulations of snow and ice

Sunmodule Plus:
Positive performance tolerance

25-year linear performance warranty and
10-year product warranty

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25 years linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance degression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry. In addition, SolarWorld is offering a product warranty, which has been extended to 10 years.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

MADE IN USA

UL 1703

ISO 9001
ISO 14001
Certified

solarworld.com

We turn sunlight into power.

Sunmodule® Plus SW 275 mono

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

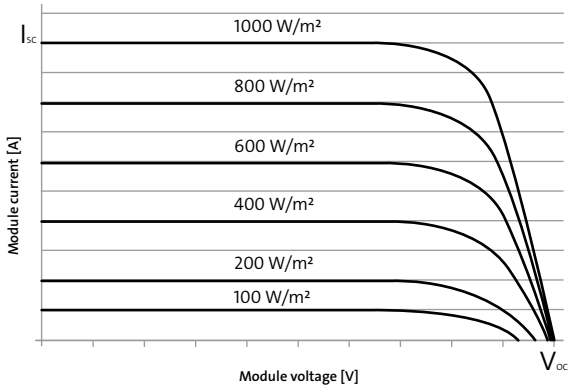
Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A

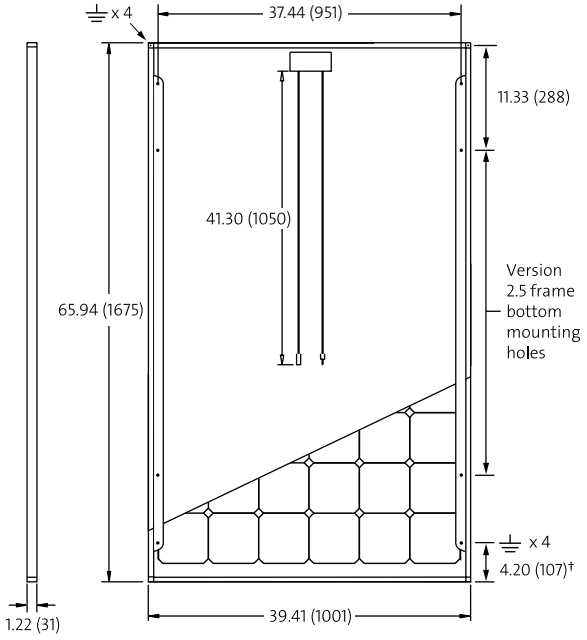
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.004 %/K
TC V_{oc}	-0.30 %/K
TC P_{mpp}	-0.45 %/K
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205.0 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	60
Cell type	Mono crystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	46.7 lbs (21.2 kg)

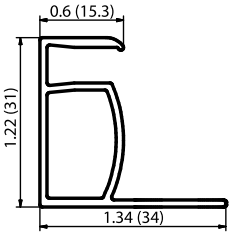
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II		1000 V
Max. system voltage USA NEC		600 V
Maximum reverse current		16 A
Number of bypass diodes		3
UL Design Loads*	***Two rail system***	113 psf downward 64 psf upward
UL Design Loads*	***Three rail system***	170 psf downward 64 psf upward
IEC Design Loads*	***Two rail system***	113 psf downward 50 psf upward

* Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting[1]	-0 Wp / +5 Wp
J-Box	IP65
Connector	MC4
Module efficiency	16.40 %
Fire rating (UL 790)	Class C



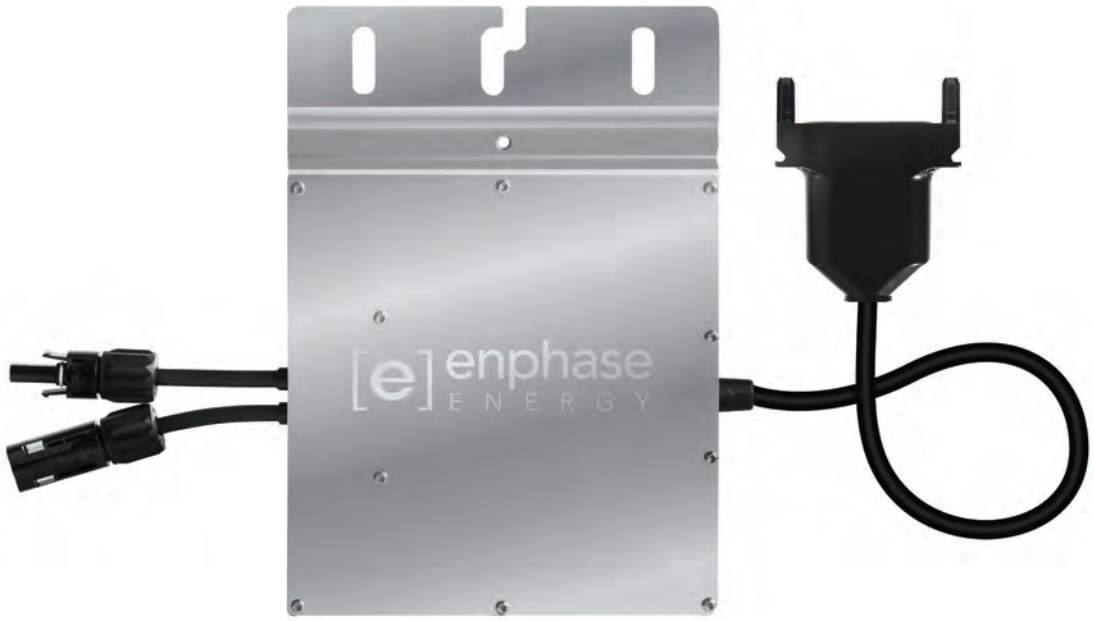
VERSION 2.5 FRAME

- Compatible with both "Top-Down" and "Bottom" mounting methods
- ⏚ Grounding Locations:
  - 4 corners of the frame
  - 4 locations along the length of the module in the extended flange†

NEW!

Independently created PAN files now available.
Ask your account manager for more information.

Enphase® **M250**



The **Enphase® M250 Microinverter** delivers increased energy harvest and reduces design and installation complexity with its all-AC approach. With the M250, the DC circuit is isolated and insulated from ground, so **no Ground Electrode Conductor (GEC) is required for the microinverter.** This further simplifies installation, enhances safety, and saves on labor and materials costs.

The Enphase M250 integrates seamlessly with the Engage® Cable, the Envoy® Communications Gateway™, and Enlighten®, Enphase's monitoring and analysis software.

PRODUCTIVE

- Optimized for higher-power modules
- Maximizes energy production
- Minimizes impact of shading, dust, and debris

SIMPLE

- No GEC needed for microinverter
- No DC design or string calculation required
- Easy installation with Engage Cable

RELIABLE

- 4th-generation product
- More than 1 million hours of testing and 3 million units shipped
- Industry-leading warranty, up to 25 years

INPUT DATA (DC)	**M250-60-2LL-S22/S23/S24**	
Recommended input power (STC)	210 - 300 W	
Maximum input DC voltage	48 V	
Peak power tracking voltage	27 V - 39 V	
Operating range	16 V - 48 V	
Min/Max start voltage	22 V / 48 V	
Max DC short circuit current	15 A	
Max input current	9.8 A	
OUTPUT DATA (AC)	**@208 VAC**	**@240 VAC**
Peak output power	250 W	250 W
Rated (continuous) output power	240 W	240 W
Nominal output current	1.15 A (A rms at nominal duration)	1.0 A (A rms at nominal duration)
Nominal voltage/range	208 V / 183-229 V	240 V / 211-264 V
Nominal frequency/range	60.0 / 57-61 Hz	60.0 / 57-61 Hz
Extended frequency range*	57-62.5 Hz	57-62.5 Hz
Power factor	>0.95	>0.95
Maximum units per 20 A branch circuit	24 (three phase)	16 (single phase)
Maximum output fault current	850 mA rms for 6 cycles	850 mA rms for 6 cycles
EFFICIENCY		
CEC weighted efficiency, 240 VAC	96.5%	
CEC weighted efficiency, 208 VAC	96.0%	
Peak inverter efficiency	96.5%	
Static MPPT efficiency (weighted, reference EN50530)	99.4 %	
Night time power consumption	65 mW max	
MECHANICAL DATA		
Ambient temperature range	-40°C to +65°C	
Operating temperature range (internal)	-40°C to +85°C	
Dimensions (WxHxD)	171 mm x 173 mm x 30 mm (without mounting bracket)	
Weight	2.0 kg	
Cooling	Natural convection - No fans	
Enclosure environmental rating	Outdoor - NEMA 6	
FEATURES		
Compatibility	Compatible with 60-cell PV modules.	
Communication	Power line	
Integrated ground	The DC circuit meets the requirements for ungrounded PV arrays in NEC 690.35. Equipment ground is provided in the Engage Cable. No additional GEC or ground is required.	
Monitoring	Free lifetime monitoring via Enlighten software	
Compliance	UL1741/IEEE1547, FCC Part 15 Class B, CAN/CSA-C22.2 NO. 0-M91, 0.4-04, and 107.1-01	

* Frequency ranges can be extended beyond nominal if required by the utility

To learn more about Enphase Microinverter technology, visit **enphase.com**

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Appendix C

Payback Calculation

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Tools for consumers and designers of solar

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Photovoltaic payback

Economic analysis of a photovoltaic system, with the determination of payback and chart.
Enter data of the photovoltaic energy, then the data estimated cost of the plant, then Data eletrica bill.
Verifying the results of operations in the graph and table. Repeat the data entry when you have more accurate and definitive.

System PV		Own consumption energy	
Peak power Wp	80000	Own consumption kWh/y	80834
Energy production KWh/y	80834	Cost €/kWh	.1
Decay module PV %	0.70	Own consumption €	8083
Costs		**Contribution**	
Initial cost €	416000	Contribution €/kWh	.26
Cost €/KWp	5200	initial contribution €	
Annual cost €	100	Annual contribution €	0
Final cost of disposal €	0		
Analysis period		**Bank financing**	
Years contributions	15	Mutual interests %	0.00
Years economic analysis	70	Annual loan installment €	0
Result			
Pay back [years | months]	[14 | 11]		
YTD Return (15 years)	0.03%	Cash balance (15 years)	1913
Compound interest (15 years)	0.03%	Cash balance (70 years)	441000

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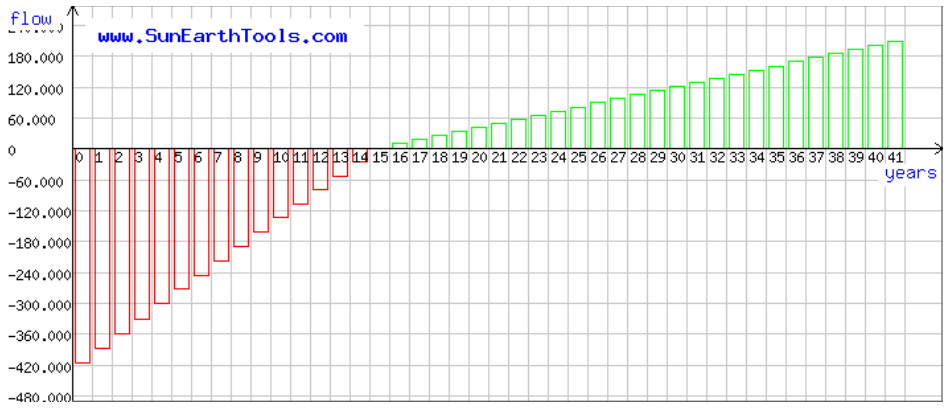

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year	flow	revenue		Prod.	Bill	Cost	Loan	YTD

Visits:
on Line:
p:1

0	-416.000	0		0	0	0	0	0.00 %
1	-387.147	28.853		20.870	8.083	-100	0	-93.06 %
2	-358.440	57.560		41.593	16.167	-200	0	-43.08 %
3	-329.878	86.122		62.172	24.250	-300	0	-26.43 %
4	-301.460	114.540		82.606	32.334	-400	0	-18.12 %
5	-273.185	142.815		102.898	40.417	-500	0	-13.13 %
6	-245.052	170.948		123.047	48.500	-600	0	-9.82 %
7	-217.061	198.939		143.056	56.584	-700	0	-7.45 %
8	-189.209	226.791		162.924	64.667	-800	0	-5.69 %
9	-161.496	254.504		182.653	72.751	-900	0	-4.31 %
10	-133.922	282.078		202.244	80.834	-1.000	0	-3.22 %
11	-106.484	309.516		221.699	88.917	-1.100	0	-2.33 %
12	-79.183	336.817		241.016	97.001	-1.200	0	-1.59 %
13	-52.017	363.983		260.199	105.084	-1.300	0	-0.96 %
14	-24.985	391.015		279.247	113.168	-1.400	0	-0.43 %
15	1.913	417.913		298.162	121.251	-1.500	0	0.03 %
16	9.897	425.897		298.162	129.334	-1.600	0	0.15 %
17	17.880	433.880		298.162	137.418	-1.700	0	0.25 %
18	25.863	441.863		298.162	145.501	-1.800	0	0.35 %
19	33.847	449.847		298.162	153.585	-1.900	0	0.43 %
20	41.830	457.830		298.162	161.668	-2.000	0	0.50 %
21	49.814	465.814		298.162	169.751	-2.100	0	0.57 %
22	57.797	473.797		298.162	177.835	-2.200	0	0.63 %
23	65.780	481.780		298.162	185.918	-2.300	0	0.69 %
24	73.764	489.764		298.162	194.002	-2.400	0	0.74 %
25	81.747	497.747		298.162	202.085	-2.500	0	0.79 %
26	89.731	505.731		298.162	210.168	-2.600	0	0.83 %
27	97.714	513.714		298.162	218.252	-2.700	0	0.87 %
28	105.697	521.697		298.162	226.335	-2.800	0	0.91 %
29	113.681	529.681		298.162	234.419	-2.900	0	0.94 %
30	121.664	537.664		298.162	242.502	-3.000	0	0.97 %
31	129.648	545.648		298.162	250.585	-3.100	0	1.01 %
32	137.631	553.631		298.162	258.669	-3.200	0	1.03 %
33	145.614	561.614		298.162	266.752	-3.300	0	1.06 %
34	153.598	569.598		298.162	274.836	-3.400	0	1.09 %
35	161.581	577.581		298.162	282.919	-3.500	0	1.11 %
36	169.565	585.565		298.162	291.002	-3.600	0	1.13 %
37	177.548	593.548		298.162	299.086	-3.700	0	1.15 %
38	185.531	601.531		298.162	307.169	-3.800	0	1.17 %
39	193.515	609.515		298.162	315.253	-3.900	0	1.19 %
40	201.498	617.498		298.162	323.336	-4.000	0	1.21 %
41	209.482	625.482		298.162	331.419	-4.100	0	1.23 %
42	217.465	633.465		298.162	339.503	-4.200	0	1.24 %
43	225.448	641.448		298.162	347.586	-4.300	0	1.26 %
44	233.432	649.432		298.162	355.670	-4.400	0	1.28 %
45	241.415	657.415		298.162	363.753	-4.500	0	1.29 %
46	249.399	665.399		298.162	371.836	-4.600	0	1.30 %
47	257.382	673.382		298.162	379.920	-4.700	0	1.32 %
48	265.365	681.365		298.162	388.003	-4.800	0	1.33 %
49	273.349	689.349		298.162	396.087	-4.900	0	1.34 %
50	281.332	697.332		298.162	404.170	-5.000	0	1.35 %
51	289.316	705.316		298.162	412.253	-5.100	0	1.36 %
52	297.299	713.299		298.162	420.337	-5.200	0	1.37 %
53	305.282	721.282		298.162	428.420	-5.300	0	1.38 %
54	313.266	729.266		298.162	436.504	-5.400	0	1.39 %
55	321.249	737.249		298.162	444.587	-5.500	0	1.40 %
56	329.233	745.233		298.162	452.670	-5.600	0	1.41 %
57	337.216	753.216		298.162	460.754	-5.700	0	1.42 %
58	345.199	761.199		298.162	468.837	-5.800	0	1.43 %
59	353.183	769.183		298.162	476.921	-5.900	0	1.44 %

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Analysis period		**Bank financing**	
Years contributions	15	Mutual interests %	0.00
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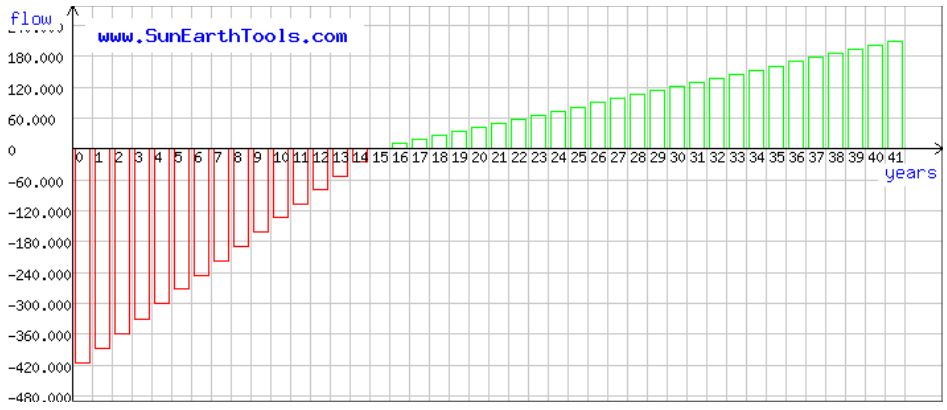

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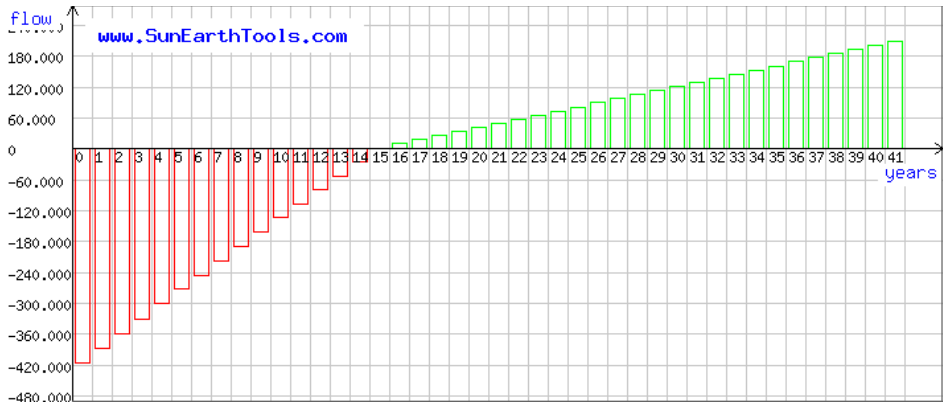

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year	flow	revenue		Prod.	Bill	Cost	Loan	YTD

Appendix F – Electrical Calculations and Cut Sheets

MERRICK & COMPANY

Engineering Calculation Sheet

Date	7/30/2014	Sheet	1	of	1
Contract					
By	staff	Chk'd	staff		

Subject:	Solar PV Systems MARFORRES
	Terre Haute, IN
	Lightning Protection Risk Assessment
	North Bldg.

Revision	By	Date	Chk'd	Date

LIGHTNING PROTECTION RISK ASSESSMENT CALCULATION

Per NFPA 780, 2011 Edition, Annex **L**, Lightning Risk Assessment, the tolerable lightning strike frequency (Nc) is compared with the expected lightning frequency (Nd). The result of this comparison is used to decide if a lightning protection system is needed. If Nd≤Nc, a lightning protection system can be optional. If Nd>Nc, a lightning protection system should be provided.

LIGHTNING STRIKE FREQUENCY (N_d)

$N_d = (N_g)(A_e)(C_1)(10^{-6})$

N_d = the yearly lightning strike frequency to the structure

N_g = the yearly average flash density in the region

A_e = the equivalent collective area of the structure (m^2)

C_1 = the environmental coefficient

N_g = 8 flashes/sq km/yr based on Vaisala Flash Density Map, Figure L.2 (a) or (b) in NFPA 780

A_e = $LW+6H(L+W)+\pi(9)(H^2)$ = 1647.8 m^2

H_2 =	0.0	ft	0	m	height of low roof
H_1 =	11.5	ft	4	m	height of high roof
L =	100.0	ft	30	m	overall building length
W =	42.0	ft	13	m	overall building width

C_1 = .25 Structure surrounded by larger structures or trees within distance of 3H

N_d = 0.0033

TOLERABLE LIGHTNING FREQUENCY (N_c)

$N_c = 1.5x10^{-3}/C$

$C = (C_2)(C_3)(C_4)(C_5)$

C_2 =	1.0	Nonmetallic structure, nonmetallic roof
C_3 =	1.0	Standard value and nonflammable
C_4 =	1.0	Normally occupied
C_5 =	1.0	Continuity of facility service not required, no environmental impact
C =	1.0	

N_c = 0.0015

0.0033	**>**	**0.0015**	**A lightning protection system should be installed**
N_d	**>**	**Nc**	

No existing lightning prot. system

MERRICK & COMPANY

Engineering Calculation Sheet

Date	7/30/2014	Sheet	1	of	1
Contract					
By	staff	Chk'd	staff		

Subject:	Solar PV Systems MARFORRES
	Terre Haute, IN
	Lightning Protection Risk Assessment
	West Bldg.

Revision	By	Date	Chk'd	Date

LIGHTNING PROTECTION RISK ASSESSMENT CALCULATION

Per NFPA 780, 2011 Edition, Annex **L**, Lightning Risk Assessment, the tolerable lightning strike frequency (Nc) is compared with the expected lightning frequency (Nd). The result of this comparison is used to decide if a lightning protection system is needed. If Nd≤Nc, a lightning protection system can be optional. If Nd>Nc, a lightning protection system should be provided.

LIGHTNING STRIKE FREQUENCY (N_d)

$N_d = (N_g)(A_e)(C_1)(10^{-6})$

N_d = the yearly lightning strike frequency to the structure

N_g = the yearly average flash density in the region

A_e = the equivalent collective area of the structure (m^2)

C_1 = the environmental coefficient

N_g = 8 flashes/sq km/yr based on Vaisala Flash Density Map, Figure L.2 (a) or (b) in NFPA 780

$A_e = LW+6H(L+W)+\pi(9)(H^2)$ = 3630.7 m^2

H_2 =	0.0	ft	0	m	height of low roof
H_1 =	19.0	ft	6	m	height of high roof
L =	151.0	ft	46	m	overall building length
W =	44.0	ft	13	m	overall building width

C_1 = .25 Structure surrounded by larger structures or trees within distance of 3H

N_d = 0.0073

TOLERABLE LIGHTNING FREQUENCY (N_c)

$N_c = 1.5x10^{-3}/C$

$C = (C_2)(C_3)(C_4)(C_5)$

C_2 =	1.0	Nonmetallic structure, metal roof
C_3 =	1.0	Standard value and nonflammable
C_4 =	1.0	Normally occupied
C_5 =	1.0	Continuity of facility service not required, no environmental impact
C =	1.0	

N_c = 0.0015

0.0073	**>**	**0.0015**	**A lightning protection system should be installed**
N_d	**>**	**Nc**	

No existing lightning prot. system

Type PRL3a

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Application Description	**V2-T3-8**
Standards and Certifications	**V2-T3-10**
Technical Data and Specifications	**V2-T3-11**
Type PRL1a	**V2-T3-26**
Type PRL1aF	**V2-T3-30**
Type PRL1a-LX	**V2-T3-34**
Type PRL2a	**V2-T3-38**
Type PRL2aF	**V2-T3-42**
Type PRL2a-LX	**V2-T3-46**
Retrofit Panelboard	**V2-T3-50**
Type PRL3a	**V2-T3-58**
Product Selection	**V2-T3-59**
Box Sizing and Selection	**V2-T3-61**
Type PRL3E	**V2-T3-62**
Type PRL4	**V2-T3-66**
Type PRL4D	**V2-T3-76**
Type PRL5P	**V2-T3-86**

Type PRL3a

Product Description

- 600 Vac maximum (250 Vdc)
- Three-phase four-wire, three-phase three-wire, single-phase three-wire, single-phase two-wire
- 800A maximum main lugs
- 600A maximum main breaker
- 225A maximum branch breakers
- Bolt-on branch breakers
- Factory assembled
- Refer to **Page V2-T3-7** for additional information

Application Description

- Lighting panelboard or power distribution panelboard
- Fully rated or series rated
- Interrupting ratings up to 200 kA symmetrical
- Suitable for use as Service Entrance Equipment, when specified on the order
- See **Pages V2-T3-7** through **V2-T3-23** for additional information

Standards and Certifications

- UL 67, UL 50
- Federal Specification W-P-115c
- Refer to **Page V2-T3-7** for additional information

Listed

Product Selection

Type PRL3a

PRL3a

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
Main Lug Only					
100	—	—	—	—	—
250	—	—	—	—	—
400	—	—	—	—	—
600	—	—	—	—	—
800 ①	—	—	—	—	—
Main Breaker					
100	18	14	—	10	EHD
100	18	14	14	10	FDB
100	22	—	—	—	EDB
100	42	—	—	—	EDS
100	65	—	—	—	ED
100	100	—	—	—	EDH
100	65	35	18	10	FD, FDE
100	100	65	25	22	HFD, HFDE
100	200	100	35	22	FDC
100	200	150	—	—	FCL
100	200	200	200	100 ②	FB-P ③
225	22	—	—	—	EDB
225	42	—	—	—	EDS
225	65	—	—	—	ED
225	100	—	—	—	EDH
225	200	—	—	—	EDC
225	65	35	18	10	FD, FDE
225	100	65	25	22	HFD, HFDE
225	200	100	35	22	FDC
250	65	35	18	10	JD
250	100	65	25	22	HJD
250	200	100	35	22	JDC
400	65	—	—	10	DK
400	65	35	25	10	KD
400	100	65	35	22	HKD
400	100	65	—	—	LHH
400	200	100	65	22	KDC
400	65	—	—	—	LCL ④
400	200	200	200	100 ②	LA-P ③④
600	65	35	18	22	LGE
600	100	65	35	22	LGH
600	200	100	50	42	LGC
600	65	35	25	22	LD
600	100	65	35	25	HLD
600	200	100	50	25	LDC
600	65	35	25	22	CLD ⑤
600	100	65	35	25	CHLD ⑤
600	200	100	50	25	CLDC ⑤

Notes

① 800A MLO requires 28-inch (711.2 mm) wide box.
② 100,000 based on NEMA test procedure.
③ Top feed only.
④ Requires 6.50-inch (165.1 mm) deep box. Not available in Type 3R, 12, 4 and 4X enclosures.
⑤ 100% rated circuit breaker. Requires copper bus. Not available in Type 12, 4 and 4X enclosures.

PRL3a Branch Circuit Breakers

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
15–60	10 ②③	—	—	—	BAB
15–60	10	—	—	—	BAB-H
70	10 ②③	—	—	—	BAB
70	10	—	—	—	BAB-H
80–100	10 ②③	—	—	—	BAB
80–100	10	—	—	—	BAB-H
15–50 ①	10 ②③	—	—	—	QBGF
15–50 ①	10	—	—	—	QBGFEP
15–20	10 ②③	—	—	—	QBCAF ④
15–60	10 ②③	—	—	—	BAB-D ⑤
15–30	10 ②③	—	—	—	BAB-C ⑥
15–30	10 ②	—	—	—	BABRP ⑦
15–30	10 ②	—	—	—	BABRSP ⑦
15–60	22 ②③	—	—	—	QBHW
15–60	22	—	—	—	QBHW-H
70	22 ②③	—	—	—	QBHW
70	22	—	—	—	QBHW-H
80–100	22 ②③	—	—	—	QBHW
80–100	22	—	—	—	QBHW-H
15–30	22	—	—	—	QBHGF
15–30	22	—	—	—	QBHGFEP
15–20	22 ②③	—	—	—	QBHCAF ④
15–20	65	14 ⑧⑨	—	—	GHQ
15–20	65	14 ⑧⑨	—	14	GHB

PRL3a Branch Circuit Breakers, continued

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
25–60	65	14 ⑧⑨	—	14	GHB
70–100	65	14 ⑧⑨	—	14	GHB
15–30	65	25 ⑧⑨	—	—	HGHB
15–20	65	14 ⑧⑨	—	14	GHQRSP ⑦
15–30	65	14 ⑧⑨	—	14	GHBS ⑦
15–60	—	14 ⑧⑨	—	—	GHBGFEP
15–20	—	14 ⑧⑨	—	—	GHBHID ⑤
15–60	18 ⑩	14 ⑧	—	10	EHD
70–100	18 ⑩	14 ⑧	—	10	EHD
15–60	18	V14	14	10	FDB
70–100	18	14	14	10	FDB
110–150	18	14	14	10	FDB
15–60	65 ⑩	35 ⑧	18	10	FD, FDE
70–100	65 ⑩	35 ⑧	18	10	FD, FDE
110–225	65 ⑩	35	18	10	FD ⑪, FDE
15–60	100 ⑩	65 ⑧	25	22	HFD, HFDE
70–100	100 ⑩	65 ⑧	25	22	HFD, HFDE
110–225	100 ⑩	65	25	22	HFD ⑪, HFDE
15–60	200	100	35	22	FDC
70–100	200	100	35	22	FDC
110–225	200	100	35	22	FDC ⑪
100–225	22	—	—	—	EDB ⑪
100–225	42	—	—	—	EDS ⑪
100–225	65	—	—	—	ED ⑪
100–225	100	—	—	—	EDH ⑪
100–225	200	—	—	—	EDC ⑪

Notes

① 50A devices are available as two-pole only.
② Single-pole breaker rated 120 Vac.
③ Two-pole breaker rated 120/240 Vac.
④ Arc fault circuit breaker.
⑤ HID (High Intensity Discharge) rated breaker.
⑥ Switching Neutral Breaker. single-pole device requires two-pole space, two-pole device requires three-pole space.
⑦ Solenoid operated breaker.
⑧ Single-pole breaker rated 277 Vac.
⑨ For use on 480Y/277V systems only.
⑩ AIC rating for two- and three-pole breakers only.
⑪ Maximum of six breakers per panel, 175–225A.

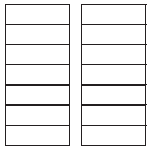
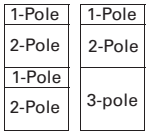
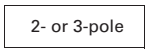
Box Sizing and Selection

Approximate Dimensions in Inches (mm)

Panel Layout Instructions

1. Select:
   a. Required mains (lugs or breaker).
   b. Neutral where required.
   c. Branch circuits as required.
2. Layout panel as shown below, using appropriate "X" dimensions.
3. Using total X units (panel height) find box height in inches (mm) and box catalog number from table below. (When total X units come out to an uneven number, use next highest number; i.e., if total X comes out 25X, use 31X.)

Layout—PRL3a

		Poles	
		6 - 3X 12 - 5X 18 - 8X 24 - 10X 30 - 13X 36 - 15X 42 - 18X	BAB, QBHW, QBCAF, BABRP, BABRSP, QBHCAF GHQ, GHB, HGHB ①
		1X 2X 3X	EDB, EDS, ED, EDH, EDC, EHD, FDB, FD, FDE, HFD, FDC, HFDE 150A max. per branch breaker (300A max. per connector)
		2X 2-Pole 3X three-pole	EDB, EDS, ED, EDH, EDC FD, HFD, FDC, ② FDE, HFDE
Neutral Section		5X 8X 11X	100–250A 400–800A 800A with through-feed lug
Main Lug Section		2X 5X 8X 14X	100A 250A 400–600A 800A
Main Breaker Section	Horizontal Mounting	2X 2-Pole 3X three-pole	EHD, FDB, FD, HFD, FDC, FDE, HFDE EDB, EDS, ED, EDH, EDC ③
	Vertical Mounting	7X 9X 14X 15X 17X 18X 21X	EHD, FDB, FD, FDE, HFD, FDC, HFDE, EDB, EDS, ED, EDH, EDC ④ FCL, FB-P ⑤ JD, HJD, JDC DK, KD, HKD, KDC, LHH LD, HLD, LDC, CLD, CHLD, CLDC LGE, LGH, LGC LCL, LA-P ⑤⑥

Notes

① GHB, HGHB and GHQ breakers cannot be mixed on same connector as BAB, QBHW, BABRP and BABRSP.
② Maximum of six breakers per panel.
③ Horizontal mounted 15–150A main breakers EHD, FDB, FD, FDE, HFD, HFDE and FDC, will be furnished as branch breaker construction. Branch breakers single-, two- or three-pole as required, may be located opposite these main breakers.
④ If optional terminal kit 3TA225FDK is required, use 10X.
⑤ FB-P and LA-P top mounting only.
⑥ LCL or LA-P main breaker requires 6-1/2-inch (165.1 mm) deep box.

Layout Example

1. Description of Panel
   Type PRL3a three-phase, four-wire, 120/208 Vac flush mounting. Panel to have short-circuit rating of 22,000 symmetrical amperes. Main breaker 400A, three-pole, bottom mounting. Branch circuits bolt-on as follows:
   12–200A single-pole QBHW
   1–200A three-pole ED
   1–225A three-pole ED
2. Layout Information from **Layout—PRL3a** table (left):
   a. 400A Neutral . . . . . = 8X
   b. 12-poles of QBHW . . . . . = 5X
   c. Two three-pole ED breakers . . = 6X
   d. Main breaker, 400A,
      Three-pole DK . . . . . = 15X
      Total Height . . . . . = 34X
3. From **Box Tabulation—PRL3a** table (below):
   a. 34X Height (use 40X box)
   b. Box Height 72 inches (1828.8 mm)
   c. Box Catalog Number . . . . . **YS2072** or **EZB2072R**

Box Tabulation—PRL3a

"X" Units	Box Height	YS Box Catalog Number	LT Trim Catalog Number	EZ Box Catalog Number	EZ Trim Catalog Number
100–400A					
14X	36.00 (914.4)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
23X	48.00 (1219.2)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
31X	60.00 (1524.0)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
40X	72.00 (1524.0)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
53X	90.00 (2286.0)	**YS2090**	**LT2090S or F**	**EZB2090R**	**EZT2090S or F**
600A					
23X	48.00 (1219.2)	**YS2048**	**LTV2048S or F**	**EZB2048R**	**EZTV2048S or F**
31X	60.00 (1524.0)	**YS2060**	**LTV2060S or F**	**EZB2060R**	**EZTV2060S or F**
40X	72.00 (1524.0)	**YS2072**	**LTV2072S or F**	**EZB2072R**	**EZTV2072S or F**
53X	90.00 (2286.0)	**YS2090**	**LTV2090S or F**	**EZB2090R**	**EZTV2090S or F**
800A					
23X	48.00 (1219.2)	**YS2848**	**LTV2848S or F**	—	—
31X	60.00 (1524.0)	**YS2860**	**LTV2860S or F**	—	—
40X	72.00 (1524.0)	**YS2872**	**LTV2872S or F**	—	—
53X	90.00 (2286.0)	**YS2890**	**LTV2890S or F**	—	—

Cabinets

Fronts are code-gauge steel, ANSI-61 light gray painted finish.

Boxes are code-gauge galvanized steel without knockouts. Standard depth is 5-3/4 inches (146.1 mm).

Standard widths are:
20-inch (508.0 mm)
100–600A.
28-inch (711.2 mm)
800A.

Standard Depth

5-3/4 inches (146.1 mm).

Top and Bottom Gutters

5-1/2 inches (139.7 mm) minimum.

Side Gutters

4 inches (101.6 mm) minimum.

Type PRL1a

Contents

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Technical Data and Specifications	**V2-T3-11**
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Type PRL1a-LX	**V2-T3-34**
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Type PRL5P	**V2-T3-86**

Type PRL1a

Product Description

- 240 Vac maximum
- Three-phase four-wire, three-phase three-wire, single-phase three-wire, single-phase two-wire
- 400A maximum mains
- 100A maximum branch breakers
- Bolt-on or plug-on branch breakers
- Each branch connector is capable of up to a total of 140A maximum by breaker ampere rating
- Factory assembled
- Refer to **Page V2-T3-7** for additional information

Application Description

- Lighting branch panelboard
- Fully rated or series rated
- Interrupting ratings up to 200 kA symmetrical
- Suitable for use as Service Entrance Equipment, when specified on the order
- See **Pages V2-T3-7** through **V2-T3-23** for additional information

Standards and Certifications

- UL 67, UL 50
- Federal Specification W-P-115c
- Refer to **Page V2-T3-7** for additional information

UL Listed

Product Selection

Type PRL1a

PRL1a

Ampere Rating	Interrupting Rating (kA Sym.) 240 Vac	Breaker Type
Main Lug Only		
100	—	—
225	—	—
400	—	—
Main Breaker		
100	10	BAB
100	18	EHD
100	22	QBHW
100	22	EDB
100	42	EDS
100	65	ED
100	65	FD, FDE
100	100	EDH
100	100	HFD, HFDE
225	22	EDB
225	42	EDS
225	65	ED
225	100	EDH
250	65	JD
250	100	HJD
250	200	JDC
400	65	DK
400	65	KD
400	100	HKD
400	100	LHH
400	200	KDC

PRL1a Branch Circuit Breakers

Bolt-on = BAB, QBHW, QBGF, QBHGF, QBGFEP, QBHGFEP, QBAF, QBAG, QBHAF, QBHAG
Plug-on = HQP, QPHW, QPGF, QPHGF, QPGFEP, QPHGFEP

Ampere Rating	Interrupting Rating (kA Sym.) 240 Vac ①	Breaker Type
15–60	10	BAB, HQP
70	10	BAB, HQP
80–100	10	BAB, HQP
15–50 ②	10	QBGF, QPGF ③
15–50 ②	10	QBGFEP, QPGFEP ④
15–20	10	QBCAF ⑤
15–60	10	BAB-D, HQP-D ⑥
15–30	10	BAB-C, HQP-B ⑦
15–30	10	BABRP ⑧
15–30	10	BABRSP ⑧
15–60	22	QBHW, QPHW
70	22	QBHW, QPHW
80–100	22	QBHW, QPHW
15–30	22	QBHGF, QPHGF ③
15–30	22	QBHGFEP, QPHGFEP ④
15–20	22	QBHCAF ⑤
Provision	—	—

Notes

① Single-pole breakers are rated 120 Vac maximum.
② 50A devices are available as two-pole only.
③ GFCI for 5 mA personnel protection.
④ GFP for 30 mA equipment protection.
⑤ Arc fault circuit breaker.
⑥ HID (High Intensity Discharge) rated breaker.
⑦ Switching Neutral Breaker. single-pole device requires two-pole space, two-pole device requires three-pole space.
⑧ Solenoid operated breaker.

Box Sizing and Selection

Approximate Dimensions in Inches (mm)

Assembled Circuit Breaker Panelboards and Lighting Controls

Box size and box and trim catalog numbers for all standard panelboard types are found on **Page V2-T3-29**.

Instructions

1. Using description of the required panelboard, select the rating and type of main required.
2. Count the total number of branch circuit poles, including provisions, required in the panelboard. Do not count main breaker poles. Convert two- or three-pole branch breaker to single-poles, i.e., three-pole breaker, count as three poles. Determine sub-feed breaker or through-feed lug requirements.
3. Select the main ampere rating section from table on **Page V2-T3-29**.
4. Select panelboard type from first column, main breaker frame, if applicable, from second column, and sub-feed breaker frame, if applicable, from the third column.
5. From Step #2, determine the number of branch circuits in Column 4.
6. Read box size, box and trim catalog numbers across columns to the right. Specify surface or flush mounting on the order.

Cabinets

Fronts are code-gauge steel, ANSI-61 light gray painted finish.

Boxes are code-gauge galvanized steel without knockouts. Standard depth is 5-3/4 inches (146.1 mm). Standard width is 20 inches (508.0 mm). An optional 28-inch (711.2 mm) wide box is available.

Top and Bottom Gutters

5-1/2 inches (139.7 mm) minimum.

Approximate Dimensions in Inches (mm)

PRL1a Panelboard Sizing

Panelboard Types	Main Breaker Types and Mounting Position (H) = Horizontal (V) = Vertical	Sub-Feed Breaker Types and Mounting Position (H) = Horizontal (V) = Vertical	Maximum No. of Branch Circuits Including Provisions	Box Dimensions ① Height	Width	Depth	YS Box Catalog Number	LT Trim Catalog Number	EZ Box Catalog Number	EZ Trim Catalog Number
100A										
Main breaker	BAB, QBHW (H)	—	15	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	27	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	39	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
Main lugs or main breaker	EHD FD, HFD (V)	—	18	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
Main lugs or main breaker with 100A through-feed lugs or sub-feed breaker	EHD FD HFD (V)	EHD FD HFD (V)	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
225A										
Main lugs or main breaker	EDB, EDS, ED, EDH, FD, HFD (V)	—	18	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
Main lugs or main breaker with 225A throughfeed lugs or sub-feed breaker	FD, HFD, EDS, ED, EDH (V)	FD, HFD, EDS, ED, EDH (V)	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
400A										
Main breaker	DK, KD, HKD, KDC, LHH (V)	—	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
		—	42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
Main lugs or main breaker with 225A through-feed lugs or sub-feed breaker	DK, KD, HKD, KDC, LHH (V)	FD, HFD, EDS, ED, EDH (V)	18	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			42	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
Main breaker with 400A through-feed lugs or sub-feed breaker	DK, KD, HKD, KDC, LHH (V)	DK, KD, HKD, KDC (V)	18	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
			30	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
			42	90.00 (2286.0)	20.00 (508.0)	5.75 (146.1)	**YS2090**	**LT2090S or F**	**EZB2090R**	**EZT2090S or F**

Note

① Smaller panelboard box sizes are available if required. Contact Eaton for application information.

Sunmodule® Plus SW 275 mono

TUV Power controlled:
Lowest measuring tolerance in industry

Every component is tested to meet
3 times IEC requirements

Designed to withstand heavy
accumulations of snow and ice

Sunmodule Plus:
Positive performance tolerance

25-year linear performance warranty and
10-year product warranty

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25 years linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance degression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry. In addition, SolarWorld is offering a product warranty, which has been extended to 10 years.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

MADE IN USA

UL 1703

ISO 9001
ISO 14001
Certified

SOLARWORLD

We turn sunlight into power.

solarworld.com

Sunmodule® Plus SW 275 mono

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

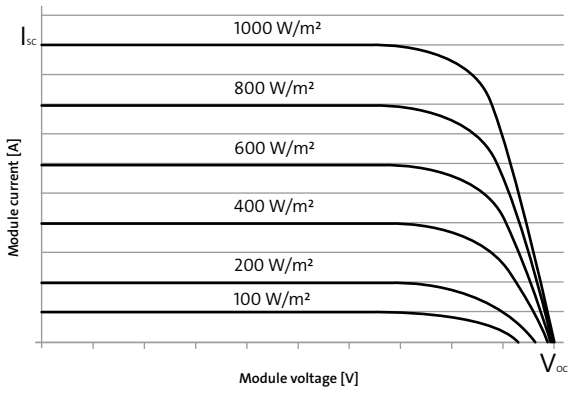
Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A

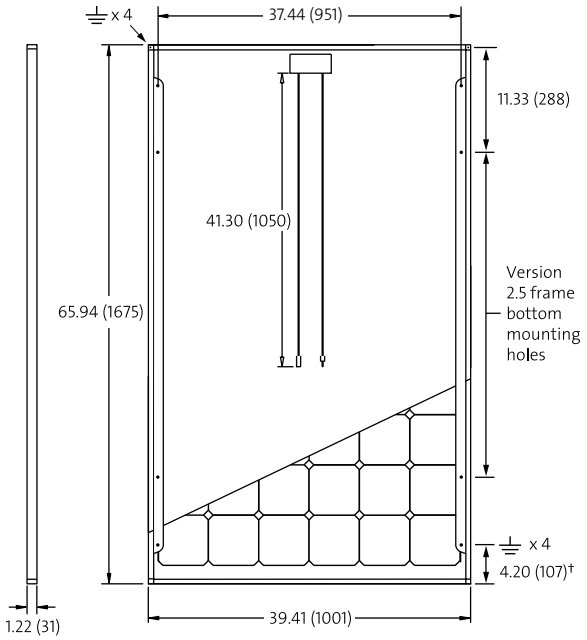
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.004 %/K
TC V_{oc}	-0.30 %/K
TC P_{mpp}	-0.45 %/K
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205.0 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	60
Cell type	Mono crystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	46.7 lbs (21.2 kg)

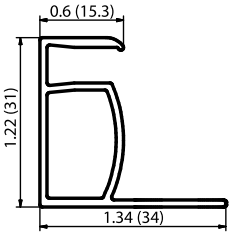
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II		1000 V
Max. system voltage USA NEC		600 V
Maximum reverse current		16 A
Number of bypass diodes		3
UL Design Loads*	***Two rail system***	113 psf downward 64 psf upward
UL Design Loads*	***Three rail system***	170 psf downward 64 psf upward
IEC Design Loads*	***Two rail system***	113 psf downward 50 psf upward

* Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting[1]	-0 Wp / +5 Wp
J-Box	IP65
Connector	MC4
Module efficiency	16.40 %
Fire rating (UL 790)	Class C



VERSION 2.5 FRAME

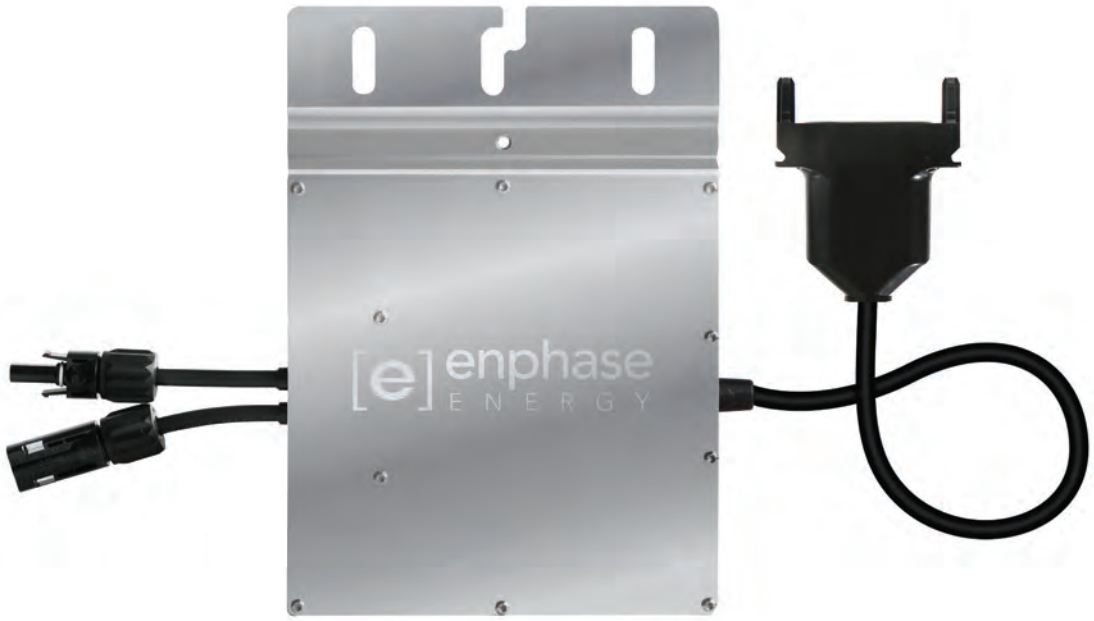
- Compatible with both "Top-Down" and "Bottom" mounting methods
- ⏚ Grounding Locations:
  - 4 corners of the frame
  - 4 locations along the length of the module in the extended flange†

NEW!

Independently created PAN files now available.
Ask your account manager for more information.

All units provided are imperial. SI units provided in parentheses.
SolarWorld AG reserves the right to make specification changes without notice.

Enphase® **M250**



The **Enphase® M250 Microinverter** delivers increased energy harvest and reduces design and installation complexity with its all-AC approach. With the M250, the DC circuit is isolated and insulated from ground, so **no Ground Electrode Conductor (GEC) is required for the microinverter.** This further simplifies installation, enhances safety, and saves on labor and materials costs.

The Enphase M250 integrates seamlessly with the Engage® Cable, the Envoy® Communications Gateway™, and Enlighten®, Enphase's monitoring and analysis software.

PRODUCTIVE

- Optimized for higher-power modules
- Maximizes energy production
- Minimizes impact of shading, dust, and debris

SIMPLE

- No GEC needed for microinverter
- No DC design or string calculation required
- Easy installation with Engage Cable

RELIABLE

- 4th-generation product
- More than 1 million hours of testing and 3 million units shipped
- Industry-leading warranty, up to 25 years

[e] enphase® ENERGY

C US

INPUT DATA (DC)	**M250-60-2LL-S22/S23/S24**	
Recommended input power (STC)	210 - 300 W	
Maximum input DC voltage	48 V	
Peak power tracking voltage	27 V - 39 V	
Operating range	16 V - 48 V	
Min/Max start voltage	22 V / 48 V	
Max DC short circuit current	15 A	
Max input current	9.8 A	
OUTPUT DATA (AC)	**@208 VAC**	**@240 VAC**
Peak output power	250 W	250 W
Rated (continuous) output power	240 W	240 W
Nominal output current	1.15 A (A rms at nominal duration)	1.0 A (A rms at nominal duration)
Nominal voltage/range	208 V / 183-229 V	240 V / 211-264 V
Nominal frequency/range	60.0 / 57-61 Hz	60.0 / 57-61 Hz
Extended frequency range*	57-62.5 Hz	57-62.5 Hz
Power factor	>0.95	>0.95
Maximum units per 20 A branch circuit	24 (three phase)	16 (single phase)
Maximum output fault current	850 mA rms for 6 cycles	850 mA rms for 6 cycles
EFFICIENCY		
CEC weighted efficiency, 240 VAC	96.5%	
CEC weighted efficiency, 208 VAC	96.0%	
Peak inverter efficiency	96.5%	
Static MPPT efficiency (weighted, reference EN50530)	99.4 %	
Night time power consumption	65 mW max	
MECHANICAL DATA		
Ambient temperature range	-40°C to +65°C	
Operating temperature range (internal)	-40°C to +85°C	
Dimensions (WxHxD)	171 mm x 173 mm x 30 mm (without mounting bracket)	
Weight	2.0 kg	
Cooling	Natural convection - No fans	
Enclosure environmental rating	Outdoor - NEMA 6	
FEATURES		
Compatibility	Compatible with 60-cell PV modules.	
Communication	Power line	
Integrated ground	The DC circuit meets the requirements for ungrounded PV arrays in NEC 690.35. Equipment ground is provided in the Engage Cable. No additional GEC or ground is required.	
Monitoring	Free lifetime monitoring via Enlighten software	
Compliance	UL1741/IEEE1547, FCC Part 15 Class B, CAN/CSA-C22.2 NO. 0-M91, 0.4-04, and 107.1-01	

* Frequency ranges can be extended beyond nominal if required by the utility

To learn more about Enphase Microinverter technology,
visit **enphase.com**

enphase® ENERGY

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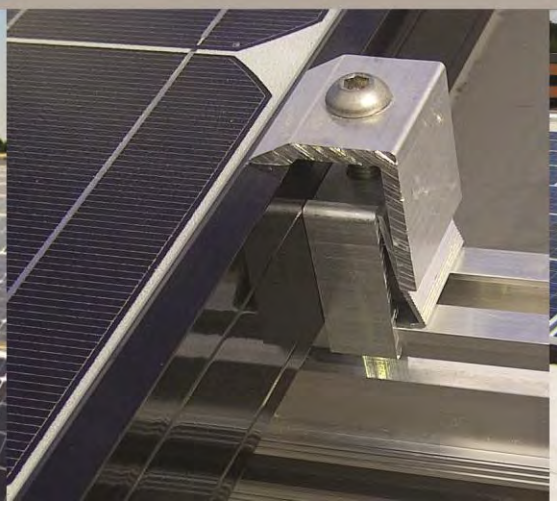
Renusol
Solar Mounting Systems

Product Catalog

Effective April 2013

Note: New items are highlighted in YELLOW



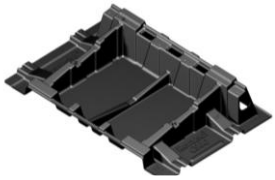
1292 Logan Circle
Atlanta, GA 30318
+1 877 847 8919

www.renusolamerica.com
info@renusolamerica.com

Renusol
Solar Mounting Systems

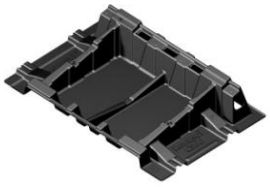
Renusol CS60

Ballasted Flat Roof System



10° Tilt System

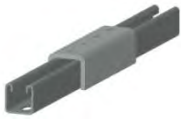
15° Tilt System

Picture	Part Number	Description	Quantity	Composed of
	**560089**	**Renusol CS60 10° Tilt**	**10-pack**	• 10 x Renusol CS60 10° HMWPE base and mounting hardware for 10° Renusol S60's
	560090	**Renusol CS60 10° Tilt**	**60-pack**	• 60 x Renusol CS60 10° HMWPE base and mounting hardware for 60 Renusol S60's
	460304	**Renusol CS60 10° Tilt- HL**	**40-pack***	• 40 x Renusol CS60 10° High Load HMWPE base and mounting hardware for 60 Renusol S60's
	*Min order qty: 480 pcs			
	560077	**Renusol CS60 15° Tilt**	**10-pack**	• 10 x Renusol CS60 15° HMWPE base and mounting hardware for 10 Renusol S60's
	560079	**Renusol CS60 15° Tilt**	**60-pack**	• 60 x Renusol CS60 15° HMWPE base and mounting hardware for 60 Renusol CS60's
	460222	**Renusol CS60 15° Tilt - HL**	**40-pack***	• 40 x Renusol CS60 15° High Load HMWPE base and mounting hardware for 40 Renusol CS60's
	*Min order qty: 480 pcs			
	500092	**Drill Jig**	**Each**	• 1 x adjustable drill jig for proper hole placement
	600036	**Accessory Hardware Kit (for micro inverter mounting, etc)**	**20-pack**	• 22 x ¼-20 clip nut • 22 x ¼-20 bolt 1.0" with self -locking patch • 22 x 1.25" OD x 0.281 ID x washer
	560094	**Anchor Bracket Kit**	**8-pack**	• 8 x anchor bracket assembly for roof anchoring **Flashing and roof screws are NOT included. These components need to be selected based on specific roof construction.**
	600403	**Assembly Tool Kit**	**Each**	• 1 x flexible drill shaft extension with right angled drive attachment

Questions, Call +1 877 847 8919 or email: info@renusolamerica.com

Renusol CS60 Additional Resources

Below is a list of possible tools/products that may assist your team in product installation. Renusol America does not guarantee or recommend any manufacturers' products. This list offers possible resources only. Each product use should be evaluated as the best tool for a particular project and installation team.

Picture	Item Suggestion	Part Number	Purpose	Online Information	Where To Find
	Solid Concrete Blocks suggested size: 4" x 8" x 16"	**Unknown**	**Product ballast if needed**	http://oldcastleproductguide.com/locations	**Distributors of Old Castle, etc.**
	Tyco Electronics Grounding Clip	**1954381-3**	**Module grounding**	http://www.te.com/catalog/products/en?q=1954381-3 **On other sites this item may be referenced as a Solklip. Please make sure to check the product number to verify correct part.**	**Distributors of Tyco Electronics**
	**Unistrut 12 gage 1 5/8 x 1 5/8 strut and U-shaped splice fitting. Use hot-dipped galvanized parts only.**	**Unistrut strut # P1000T-HG Unistrut Splice # P1377-HG**	**Connecting North/South if needed**	www.unistrut.us	**Distributors of Unistrut or competitors**
	EPDM Slip Sheet	**Variety of different manufacturers**	**Use if needed for roof surface**		**Distributors of commercial roofing. Also available through Allied Building Products.**

General information:

- All transactions according to 'Renusol America Inc. General Terms and Conditions of Sale'*
- All prices are in US$; customer discount to be deducted, including packaging, excluding VAT and freight charge.
- Payment terms are 'cash in advance', unless other terms have been agreed upon (after credit approval).
- Delivery Freight on Board (FOB) destination, Freight Prepaid and added to the invoice.
- We reserve the right to make changes in the form, technique, dimension, weight and material for the purpose of technical improvement.
- Errors and omissions excluded.
- With the present pricelist all previous pricelists have become invalid.

Renusol America Inc.
1292 Logan Circle NW
Atlanta, GA 30318

For further information: Info@renusolamerica.com
Toll-free: + 1 877 847 8919
Fax: +1 678 669 2743

Submit orders to: Order@renusolamerica.com

***Complete General Terms and Conditions of Sale and product warranties are listed in the following pages.**

General Terms & Conditions of Sale

1. General Provisions

1.1 All sales of the products and services of Renusol America Inc. ("Supplier") to buyers ("Customer"; Supplier and Customer are referred to individually as a "Party" or jointly as the "Parties") of Renusol America Inc. brand products are subject to these general terms and conditions of sale (this "Agreement").

1.2 No order will be accepted by Supplier until Customer has indicated in writing on a "Sales Order Confirmation" form, referred to below, that it has agreed to the terms of this Agreement.

2. Order Placement

2.1 A sales quotation given in response to any request is for the potential Customer's reference only and is not legally binding on either Party unless otherwise expressly stated therein.

2.2 All orders for the Renusol mounting systems and related accessories (the "Product") manufactured, assembled, or otherwise distributed by Supplier, must be received on a "Purchase Order" form selected by Customer or Supplier.

2.3 All orders must be submitted with a delivery date and ship-to address. If a delivery date is not listed on order, shipments will be held for up to 30 days only

3. Prices And Terms Of Payment

3.1 The price per Product (the "Purchase Price") shall be as set forth in a Sales Order Confirmation to be faxed or e-mailed to Customer for approval. Such Sales Order Confirmation will be prepared by Supplier after receipt from Customer of the Purchase Order confirming the quantity and delivery requirements of Customer. The Supplier's Sales Order Confirmation requires a signature from Customer in order for Supplier to proceed with the order.

3.2 Payments are due upon receipt, or **net 30 days** if customer has a credit agreement in place. Further discounts on Purchase price shall be applicable as special promotions, as announced on sales quotation form.

3.3 Upon completion of production of the Product prepared pursuant to the Sales Order Confirmation, Supplier will notify Customer by fax, e-mail, or phone that the order is ready for shipment upon receipt of the balance of the Purchase Price for the total order. Upon receipt of the payment for the entire amount of the Purchase Price, Supplier will promptly ship the Product to Customer in the manner specified in the Purchase Order and confirmed in the Sales Order Confirmation.

3.4 Unless specific arrangement is made for an extension of credit, payment is due prior to the time of delivery. Finance charges equal to the lesser of 1.5% per month (18% per annum) or the maximum rate permitted by applicable law may be assessed on payments received after delivery has been made from such delivery date to the date payment is received. If an extension of credit has been made, payment is due net the number of days set forth on the Sales Order Confirmation from the date delivery has been made (the "Payment Due Date"). An extension of credit shall be deemed to have been made whenever payment in full is not made prior to the time of delivery. Failure to make payments when due or remit finance charges when assessed may result in delayed or cancelled shipments. No unauthorized deductions from invoices are permitted.

3.5 Customer will also be required to pay all sales or use taxes unless satisfactory evidence of re-seller status or tax exempt form is provided to Supplier.

3.6 Supplier reserves the right to rescind and cancel the Sales Order Confirmation at any time if Customer breaches the payment terms referred to in this Section 3 of this Agreement.

3.7 The Purchase Price shall be paid in cash, either by wire transfer, check or other mutually agreed method. Additionally, to the extent lawful, and if approved by Supplier, all or any portion of the Purchase Price may be paid by an assignment by Customer to Supplier of rights to payment in respect of any incentive payments, rebates or similar payments available to Customer from third parties in connection with the installation of the Product (such payments and rebates are herein referred to as "Product Incentive Payments"). Customer shall be responsible for preparation and delivery of any documentation necessary to assign any Product Incentive Payments approved for payment by Supplier. Additionally, if any applicable third party fails to make any Product Incentive Payment at the time due (or expected to be due), Customer shall not be relieved from making such payment, and shall upon the request of Supplier promptly make such payment to Supplier.

4. Shipment Terms And Limitations

4.1 All risk of loss for damage to the Product ordered, in whole or in part, shall be borne entirely by Customer once the Product is delivered to a common carrier for delivery to Customer pursuant to the terms of the Sales Order Confirmation.

4.2 Any estimate by Supplier to Customer for the cost and time of delivery of the Product is only an estimate, and time of delivery shall be automatically extended by a reasonable period of time due to unforeseen causes beyond the responsibility of Supplier.

5. Miscellaneous Terms

5.1 The Sales Order Confirmation signed by both Parties may not be modified, amended or altered in any manner without the mutual written consent of both Parties.

5.2 This Agreement and any other documents referred to in this Agreement constitute the entire agreement between the Parties regarding the subject matter contained herein and shall supersede all previous oral or written agreement(s) between the Parties. **To the extent any other document, including a Purchase Order, is inconsistent with the terms of this Agreement, the terms of this Agreement shall prevail unless expressly acknowledged in the Sales Order Confirmation.**

6. Warranty And Limitation Of Liability

6.1 The warranty terms are set forth in the accompanying document titled "Renusol America, Inc., 10 Year Limited Product Warranty for Renusol VS" and/or "Renusol America, Inc., 25 Year Limited Warranty for Renusol CS60".

7. CHOICE OF LAW AND DISPUTE RESOLUTION

7.1 **Governing Law**. This Agreement and all documents executed and delivered in connection herewith shall be construed and enforced in accordance with the laws of the State of Georgia, except with respect to conflicts of laws principles.

7.2 Dispute Resolution.

7.2.1 **Arbitration**. Any disputes that cannot be resolved by the Parties themselves shall be resolved by binding arbitration in Atlanta, Georgia, conducted in accordance with the commercial arbitration rules of the American Arbitration Association. The arbitrator(s) in such arbitration shall be authorized and instructed to award to the prevailing Party, as part of its award, an amount equal to the prevailing Party's costs of arbitration, including, without limitation, reasonable attorneys' fees.

7.2.2 **Enforcement of Arbitral Award - Consent to Jurisdiction.** Each of the Parties hereby irrevocably consents and agrees that any legal action or proceedings brought to enforce any arbitral award granted pursuant to this Agreement may be brought in state and federal courts located in Atlanta, Georgia.

8. NOTICES

8.1 Any notice required by this Agreement or given in connection with it shall be in writing and shall be given to the appropriate Party by personal delivery or by certified mail, postage prepaid, or recognized overnight delivery services.

Renusol America, Inc. – 25 Year Limited Product Warranty for Renusol CS60

Renusol America, Inc. ("Seller") warrants to the original buyer ("Buyer") that this product(s) ("Product") shall be free from defects in material and workmanship. If the Product or any of its components is found defective during the Warranty Period, Seller will repair or replace, at Seller's sole discretion, the Product or component with the same or a similar model, which may be a reconditioned unit, without charge for parts or labor. This warranty ("Warranty") shall be in effect for a period of twenty-five (25) years from the earlier of: (i) the date that the initial installation of the Product is completed; or (ii) 30 days after the purchase of the Product by the Buyer (the "Warranty Period"). However, for specified components generally, or for a particular type of use of certain components, the term of the warranty may be shorter as expressly specified or provided for by Seller's individually-generated plans for the pertinent project. If a shorter warranty is specified as to any component, or if an exchange of a component is otherwise scheduled within a shorter period, the Warranty Period shall be restricted to such specified shorter period.

If you need service under this Warranty, you must, prior to the lapse of the Warranty Period, file a claim, together with proof of purchase and confirmation from you that you are the original purchaser of the Product, with Seller. This Warranty is conditioned upon your reasonably cooperating with Seller in the evaluation of your claim and the implementation of any remedy.

Seller's obligation to perform under this Warranty shall not apply if: (i) installation of the Product is not performed in accordance with Seller's written installation instructions and design specifications therein, as well as generally recognized standards and principles of building and constructions work; (ii) the Product has been modified, repaired, or reworked in a manner not previously authorized, in writing, by Seller; (iii) the Product has been utilized or handled in a manner that is inconsistent with any written instructions provided to the Buyer by the Seller; (iii) the Product is installed in an environment for which it was not designed or which contains corrosive atmospheric conditions (including without limitation, chemical fumes, salt water and wind-blown sand); or (iv) Buyer does not pay all invoices promptly as due in accordance with all purchase orders, invoices, or any other contract document related to the Product.

This Warranty shall not cover the following: (i) damage from any foreign residue deposited on the finish of the Product; (ii) damage to the Product that occurs during its shipment, storage, or installation; and (iii) damage that is covered or coverable by insurance against storm or similar natural events. Manufacturers of related items, such as PV modules and flashings, may provide written warranties of their own. Seller's limited Warranty covers only its Product, and not related items.

REPAIR OR REPLACEMENT OF ANY PRODUCT UNDER THIS WARRANTY SHALL COMPLETELY SATISFY AND DISCHARGE ALL OF SELLER'S LIABILITY WITH RESPECT TO THIS WARRANTY. SELLER SHALL NOT BE LIABLE FOR CONSEQUENTIAL, CONTINGENT OR INCIDENTAL DAMAGES ARISING OUT OF THE USE OF THE PRODUCT BY BUYER UNDER ANY CIRCUMSTANCES. SELLER MAKES NO WARRANTY THAT THE PRODUCT WILL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE, AND MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN.

This Warranty is expressly subject to Seller's General Terms and Conditions of Sale, which are incorporated herein by reference. This Warranty extends only to claims of the original Buyer, and third parties shall have no rights or benefits under this Warranty. This Warranty is non-assignable and non-transferable without the written consent of the Seller.

RSA 2/15/2012

Renusol America, Inc. – 10 Year Limited Product Warranty for Renusol VS

Renusol America, Inc. ("Seller") warrants to the original buyer ("Buyer") that this product(s) ("Product") shall be free from defects in material and workmanship. If the Product or any of its components is found defective during the Warranty Period, Seller will repair or replace, at Seller's sole discretion, the Product or component with the same or a similar model, which may be a reconditioned unit, without charge for parts or labor. This warranty ("Warranty") shall be in effect for a period of ten (10) years from the earlier of: (i) the date that the initial installation of the Product is completed; or (ii) 30 days after the purchase of the Product by the Buyer (the "Warranty Period"). However, for specified components generally, or for a particular type of use of certain components, the term of the warranty may be shorter as expressly specified or provided for by Seller's individually-generated plans for the pertinent project. If a shorter warranty is specified as to any component, or if an exchange of a component is otherwise scheduled within a shorter period, the Warranty Period shall be restricted to such specified shorter period.

If you need service under this Warranty, you must, prior to the lapse of the Warranty Period, file a claim, together with proof of purchase and confirmation from you that you are the original purchaser of the Product, with Seller. This Warranty is conditioned upon your reasonably cooperating with Seller in the evaluation of your claim and the implementation of any remedy.

Seller's obligation to perform under this Warranty shall not apply if: (i) installation of the Product is not performed in accordance with Seller's written installation instructions and design specifications therein, as well as generally recognized standards and principles of building and constructions work; (ii) the Product has been modified, repaired, or reworked in a manner not previously authorized, in writing, by Seller; (iii) the Product has been utilized or handled in a manner that is inconsistent with any written instructions provided to the Buyer by the Seller; (iii) the Product is installed in an environment for which it was not designed or which contains corrosive atmospheric conditions (including without limitation, chemical fumes, salt water and wind-blown sand); or (iv) Buyer does not pay all invoices promptly as due in accordance with all purchase orders, invoices, or any other contract document related to the Product.

This Warranty shall not cover the following: (i) damage from any foreign residue deposited on the finish of the Product; (ii) damage to the Product that occurs during its shipment, storage, or installation; and (iii) damage that is covered or coverable by insurance against storm or similar natural events. Manufacturers of related items, such as PV modules and flashings, may provide written warranties of their own. Seller's limited Warranty covers only its Product, and not related items.

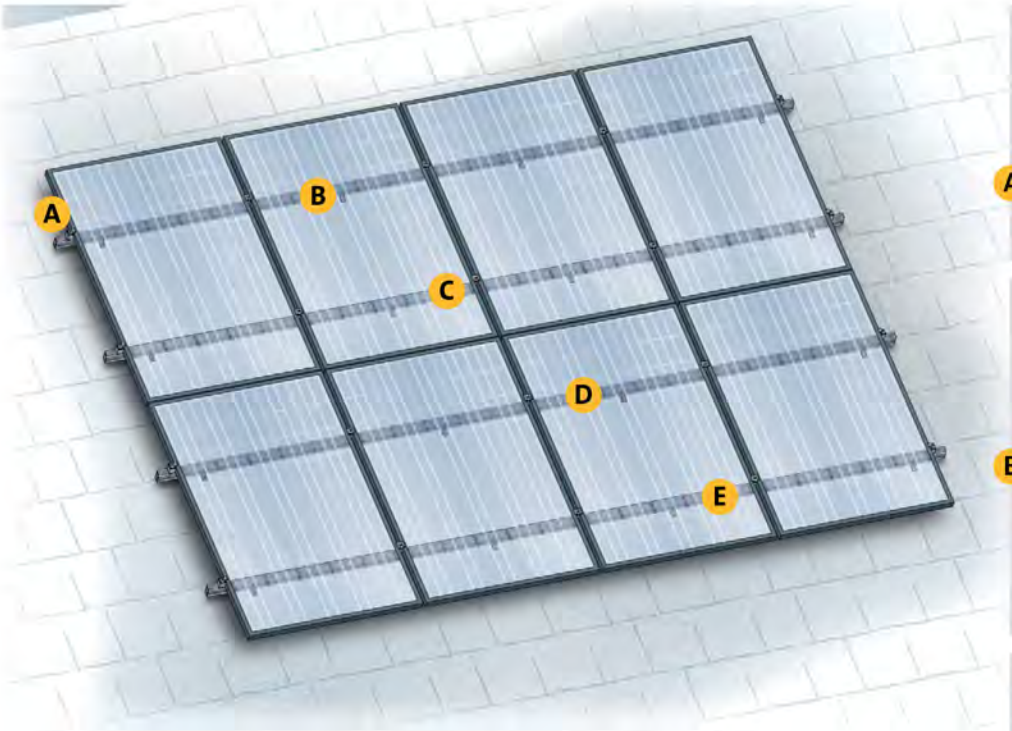
REPAIR OR REPLACEMENT OF ANY PRODUCT UNDER THIS WARRANTY SHALL COMPLETELY SATISFY AND DISCHARGE ALL OF SELLER'S LIABILITY WITH RESPECT TO THIS WARRANTY. SELLER SHALL NOT BE LIABLE FOR CONSEQUENTIAL, CONTINGENT OR INCIDENTAL DAMAGES ARISING OUT OF THE USE OF THE PRODUCT BY BUYER UNDER ANY CIRCUMSTANCES. SELLER MAKES NO WARRANTY THAT THE PRODUCT WILL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE, AND MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN.

This Warranty is expressly subject to Seller's General Terms and Conditions of Sale, which are incorporated herein by reference. This Warranty extends only to claims of the original Buyer, and third parties shall have no rights or benefits under this Warranty. This Warranty is non-assignable and non-transferable without the written consent of the Seller.

RSA 2/15/2012

Renusol VS

Solar PV Mounting System For Pitched Roof Applications



The Renusol VS system provides a simple, fast and cost effective mounting solution for PV modules on pitched roofs.

- Just one end clamp and one mid clamp part number simplifies inventory and project planning.
- Pre-assembled clamps, fastener-free splice connectors, and slide-free L-feet minimize installation time.
- Anti-slip hardware and bolt alignment indicators ensure installation confidence.
- Stainless steel hardware and 6000 series aluminum rails provide strength and long product life.
- High strength-to-weight ratio rail design keeps cost low while allowing long spans.
- WEEB-CCR offers continuous grounding of panels to rails.

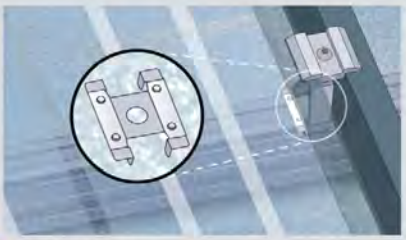
About Renusol

Renusol America is a leading innovator in flat-roof and pitch-roofed mounting systems for Solar PV modules in the US solar industry. Renusol America provides sales, service, and customer support from its headquarters in Atlanta, Georgia and through a network of authorized distributor partners across the country. The company is part of the Centrosolar Group, a publicly traded company on the German stock exchange, and is a wholly owned subsidiary of Renusol GmbH, a market leader in Europe with close to 1GW of solar power mounted on Renusol systems.

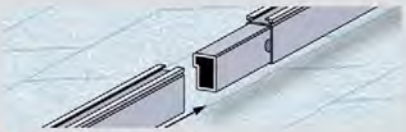
FEATURES

A End Clamp
- Clamp range from 30 to 50mm
- Fits 97% of all modules

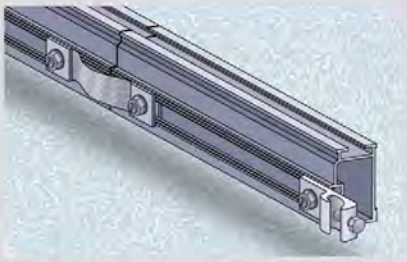
B L-Foot
- Insert anywhere without sliding
- Offset T-bolt slot for easier mounting or fastening
- Bolt alignment indicator ensures proper alignment



C Mid Clamp
- Clamp range: 30 to 50mm
- Fits 97% of all modules
- WEEB-CCR provides continuous grounding of panels to rails



D Splice Connector
- Presets rail gaps for thermal expansion
- No fastening equals quick installation



E Rail
- Continuous spans up to 12 feet
- Rail approved for side mounting of WEEBs

Renusol Solar Mounting Systems

Renusol America
1292 Logan Circle NW, Atlanta, GA 30318
www.renusolamerica.com
+1 877-847-8919

Installation Manual

Enphase Engage Cable and Accessories

Contact Information

Enphase Energy Inc.
201 1St Street
Petaluma, CA 94952
Phone: 707-763-4784 Toll Free: 877-797-4743
Fax: 707-763-0784

http://www.enphase.com

info@enphaseenergy.com

Other Information

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Important Safety Information

Read this First

To reduce the risk of electrical shock, and to ensure the safe installation and operation of the Enphase System, the following safety indications appear throughout this document.

⚠ DANGER	Indicates a hazardous situation, which if not avoided, **will** result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation, which if not avoided, **could** result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation which, if not avoided, **could** result in minor or moderate injury.
NOTICE	Follow instructions closely to avoid damage or malfunction to the device and/or damage to surrounding property.

Safety Instructions

For Your Safety

⚠ DANGER	**Risk of Electrical Shock**. Do NOT connect or disconnect the photovoltaic module from the Enphase Microinverter without first removing AC power from the photovoltaic system.

Electrical Installation

⚠ WARNING	Be aware that only trained solar professionals should install and/or replace the Enphase Cabling System or connect the Enphase Microinverter to the electrical utility grid.
⚠ WARNING	Perform all electrical installations in accordance with all local electrical codes and the National Electrical Code (NEC), ANSI/NFPA 70.
⚠ WARNING	The AC connectors on the cabling are rated as a disconnect only when used with an Enphase Microinverter.
⚠ WARNING	Connect the Enphase Microinverter to the electrical utility grid only after receiving prior approval from the utility company and any applicable AHJ (authority having jurisdiction).
NOTICE	Before installing the cabling, read all instructions and cautionary markings in the user manual, on the Enphase equipment, and on the all other photovoltaic equipment.

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The Enphase Engage Cable and Accessories

The Engage Cable is a continuous length of 2.5 mm2 (12 AWG), outdoor rated cable with integrated connectors for microinverters. These connectors are preinstalled along the Engage Cable at intervals to accommodate PV module widths. The microinverters plug directly into the cable connectors.

Compatibility

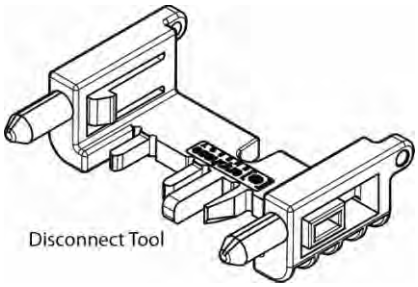
The cabling is compatible with a variety of PV racking systems. For a list of approved PV racking systems, refer to the PV Racking Compatibility document on the Enphase website (http://www.enphase.com/support/downloads).

Parts and Tools Required

In addition to the Enphase microinverters, PV modules, PV racking, and associated hardware, you will need the following items.

Enphase equipment:

- Enphase Engage Cable. See Selecting Cable Type on page 8 for options.
- Watertight sealing caps, as needed (for any unused drops on the cable)
- Terminators, as needed (for AC branch circuit cable ends)
- Cable clips
- Enphase disconnect tool (number 2 Phillips screwdriver can be substituted)



Other items:

- Outdoor-rated, weather-proof AC junction box(es)
- Grounding conductor
- Torque wrench, sockets, wrenches for mounting hardware
- Adjustable wrench or open ended wrench (for terminators)

Lightning Surge Protection

Lightning protection and resulting voltage surge are protected in accordance with EN 62305-1. It is assumed that the PV modules are installed in accordance with related standards and that the microinverter is a part of a broader lightning mitigation system in accordance with EN 62305-1, -3.

In some areas, the statistical frequency of lightning strikes near a PV installation is high enough that lightning protection must be installed as part of an Enphase system. In some areas, a surge protection device might be mandatory following a risk analysis, according NFC 15-100 (art. 443) & NFC 15-443L.

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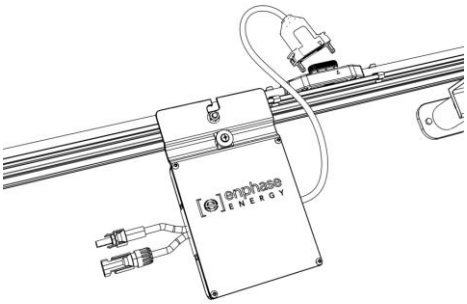
Selecting Cable Type

Enphase Engage Cable is available in two different voltage types and two connector spacing options. Depending upon installer needs, the cable is also available in different lengths.

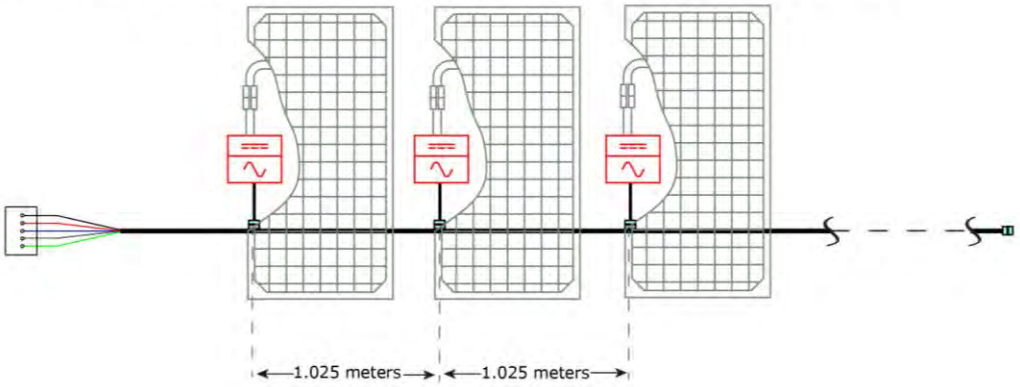
The cable is installed by simply rolling out the desired length of cable and cutting it to size. One end is wired directly into the junction box at the head of the branch circuit, eliminating the need for a separate AC interconnect cable. The other end is sealed from the environment using an Enphase Branch Terminator. The microinverter AC cable connectors are then plugged into the regularly-spaced connectors as shown.



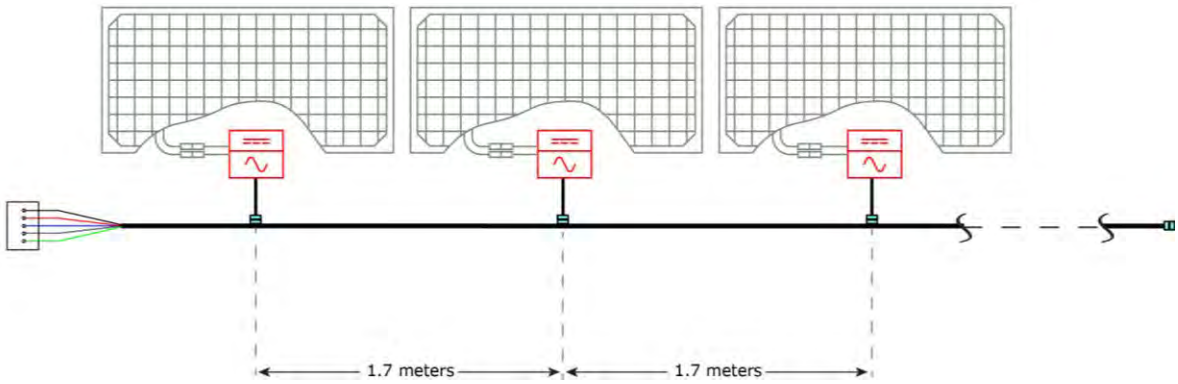
Connector Spacing Options

The gap between connectors on the cable can be either 1.025 meters (40″) or 1.7 meters (67″). The 1.025 meter spacing is best suited for connecting PV modules installed in portrait orientation, while the 1.7 meter gap is best suited to PV modules installed in landscape orientation.

Cabling with connectors spaced at 1.025 meter (40″) for PV modules in portrait orientation



Cabling with connectors spaced at 1.7 meters (67″) for PV modules in landscape orientation



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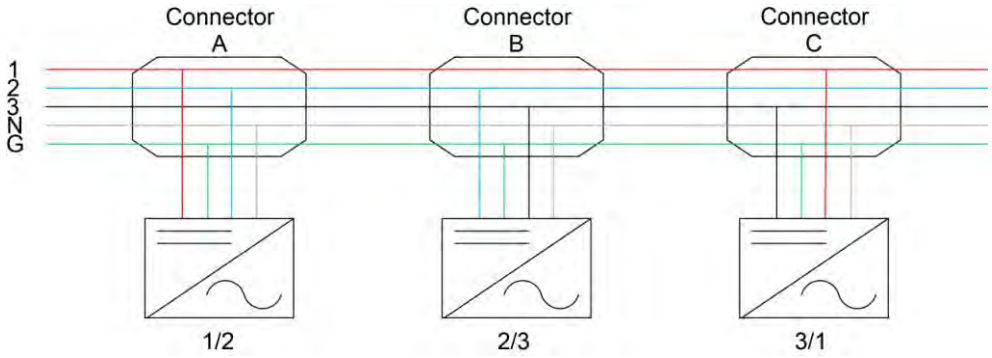
Voltage Types and Conductor Count

The voltage types are either 240VAC split phase or 208VAC three phase. **All cable connectors bear labels indicating their cable voltage designation.** Typically used for residential applications, 240VAC includes four conductors. This cabling should also be used for split phase 208VAC applications. Three-phase 208VAC cabling includes five conductors, and is used for most commercial installations. Because Enphase microinverters output onto two phases, three phase cabling balances the phases by rotating conductor use from one microinverter to the next as shown in the following diagram. In the diagram, the three phases are labeled 1, 2, and 3.



Racking Compatibility

Engage Cabling is compatible with a variety of racking systems. For a list of approved PV module racking types, refer to the Racking Compatibility document at (http://www.enphase.com/support/downloads).

Cabling Length Options

Engage Cabling is available in shorter lengths with 30-40 connectors, depending upon voltage type. Longer lengths can be ordered and cut to suit per order. Ordering options include:

Model Number	Voltage type/ conductor #	Connector count	Connector spacing	PV module orientation	Approx. weight
ET10-240-40	240VAC, 4 conductor	40	1.025 m (40″)	Portrait	18.1 kg (40 lbs)
ET17-240-40	240VAC, 4 conductor	40	1.7 m (67″)	Landscape	20.4 kg (45 lbs)
ET10-208-30	208VAC, 5 conductor	30	1.025 m (40″)	Portrait	13.6 kg (30 lbs)
ET17-208-30	208VAC, 5 conductor	30	1.7 m (67″)	Landscape	15.9 kg (35 lbs)
ET10-240-BULK	240VAC, 4 conductor	240	1.025 m (40″)	Portrait	over 90 kg (200 lbs)
ET17-240-BULK	240VAC, 4 conductor	240	1.7 m (67″)	Landscape	over 90 kg (200 lbs)
ET10-208-BULK	208VAC, 5 conductor	240	1.025 m (40″)	Portrait	over 90 kg (200 lbs)
ET17-208-BULK	208VAC, 5 conductor	240	1.7 m (67″)	Landscape	over 90 kg (200 lbs)

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Planning for Cable Lengths and Type

The Cabling System is flexible enough to adapt to almost any solar design. To determine the length and cable type that you need, take into account the following considerations:

- **The number of Enphase Microinverters to be installed on the AC branch circuit**. Be certain to allocate the correct number of connectors, including extra connectors for gaps and turns.
- **Additional length required to reach from the AC branch circuit junction box to the first microinverter**. If greater than half a connector interval is needed, it may be necessary to allow for one (or more) unused connectors in order to span this distance. Unused connectors must be covered with Enphase watertight sealing caps.
- **Additional length required to reach from one row of PV modules to the next.** If the PV modules are laid out in multiple rows, the distance from one row to the next often requires additional cabling length.
- **Bend radius**. When planning cabling turns or loops, you must account for a minimum bend radius of 6.7 cm (2.625″).
- **Multiple sub-arrays**. Often, the AC branch circuit may be composed of several smaller sub-arrays across more than one roof plane. In this case, the cable is cut to service each smaller array, and the sub-arrays are connected together using appropriately rated lengths of conduit. The transition from cable to conduit is accomplished using an outdoor rated AC junction box, as required by the NEC and local code. Unused connectors must be covered with Enphase watertight sealing caps.
- **Mixture of PV modules in both portrait and landscape orientation**. When PV modules are installed in mixed orientation (both portrait and landscape orientation), there are three choices for cabling:

    1. Cabling with 1.025 meter spacing between connectors results in cleanest install for the PV modules in portrait orientation. For PV modules placed in landscape orientation, plan for an unused connector between each PV module to accommodate the required additional distance. Unused connectors must be covered with Enphase watertight sealing caps.
    2. Cabling with 1.7 meter spacing between connectors results in cleanest install for PV modules in landscape orientation, but requires that any additional cable length between PV modules in portrait orientation be coiled and dressed so that cabling does not contact the roof. Again, unused connectors must be covered with Enphase watertight sealing caps.
    3. Another solution when PV modules are installed in mixed orientation is to transition between 1.025 and 1.7 meter spacing cable options using an outdoor rated junction box. This junction box can be installed to the PV racking.

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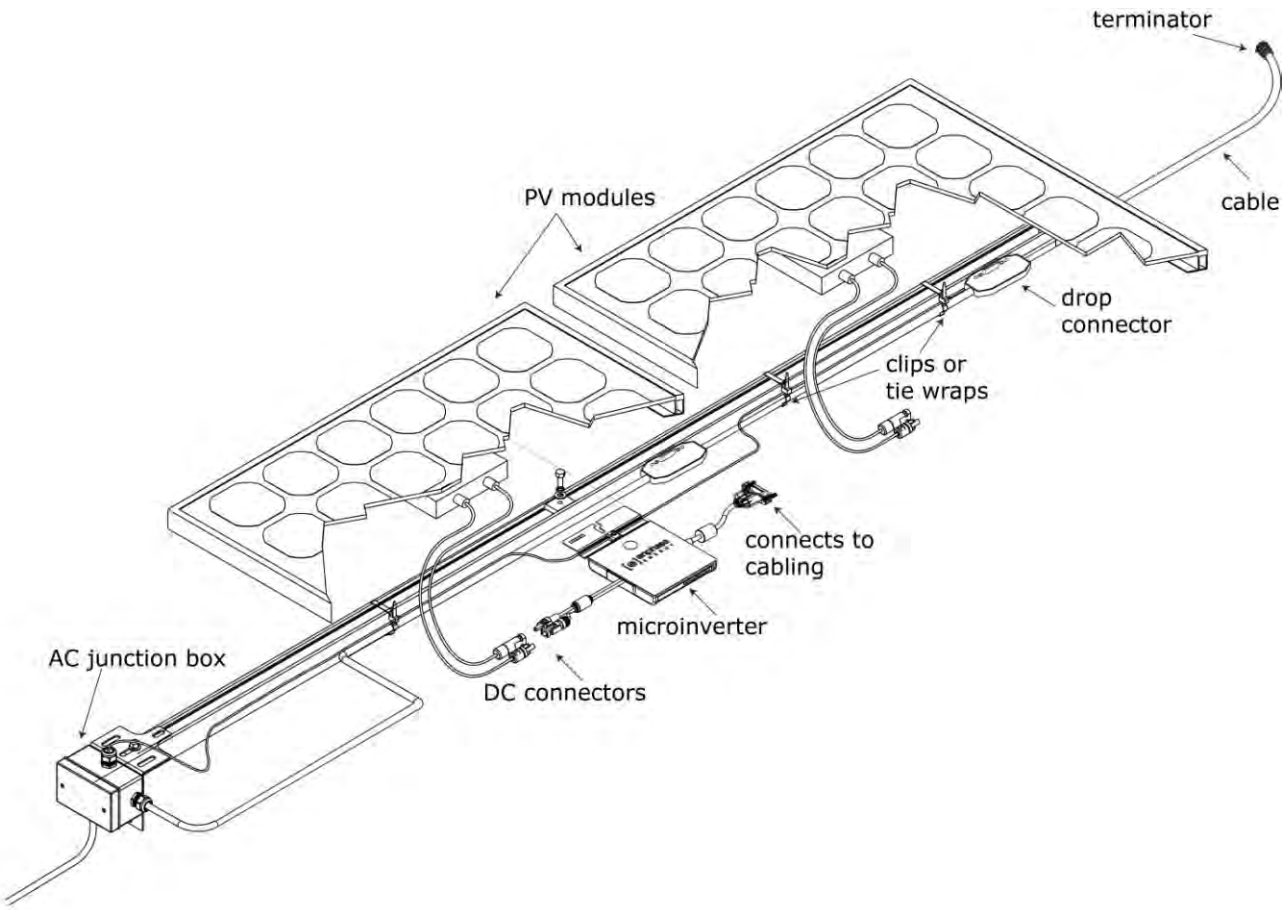
Enphase Engage Cable and Accessories Installation

Follow the instructions in this section to install the Engage Cable.

For information on microinverter installation, refer to the *M215 Installation and Operation Manual* at http://www.enphase.com/support/downloads.



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Installation Procedure

Installing the Engage Cable and Accessories involves several key steps:

1. Measure AC at Service Entrance Conductors
2. Install the AC Branch Circuit Junction Box
3. Position the Engage Cable
4. Attach the Microinverters to the Racking
5. Dress the Engage Cable
6. Terminate the Unused End of the Engage Cable
7. Connect the Engage Cable to Junction Box(es)
8. Verification and Commissioning

⚠ DANGER **Risk of Electrical Shock.** Due to presence of exposed conductors, DO NOT connect the Enphase Microinverters to the utility grid or energize the AC circuit(s) until you have completed all of the installation procedures as described in the following sections.

Step 1 – Measure AC at Service Entrance Conductors

Measure AC line voltage at the service entrance conductors. Acceptable ranges are shown in the following table.

240 Volt AC Split Phase		208 Volt AC 3 Phase	
L1 to L2	211 to 264 Vac	L1 to L2 to L3	183 to 229 Vac
L1, L2 to neutral	106 to 132 Vac	L1, L2, L3 to neutral	106 to 132 Vac

NOTICE Be sure the Engage Cable you are using matches the service at the site. Use 208Vac cabling at sites with three-phase 208Vac service, or use 240Vac cabling at sites with 240Vac service. Check the labeling on the cable drop connectors to verify the cable type.

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Step 2 – Install the AC Branch Circuit Junction Box

DANGER **Risk of Electrical Shock**. Be aware that installation of this equipment includes risk of electric shock. Do not install the junction box without first removing AC power from the Enphase System.

NOTICE Use electrical system components approved for wet locations only.

NOTICE When stripping off the cable sheath, make sure that the conductors are not damaged.

NOTICE Do not weigh down the cabling system.

NOTICE Loose cables might become a tripping hazard. Attach the power cables correctly.

NOTICE Do NOT exceed the maximum number of microinverters in an AC branch circuit as listed on page 7 of this manual, and protect each microinverter AC branch circuit with a 20 A maximum breaker.

a. Size the AC wire gauge to account for voltage drop. Select the correct wire size based on the distance from the beginning of the microinverter branch circuit to the breaker in the load center.

All components of system wiring must be considered, including internal voltage drop within the length of Engage Cable. Typically, three wire sections and several wire terminations must be quantified. There is also some resistance associated with each OCPD (OverCurrent Protective Device), typically a circuit breaker. As all of these resistances are in series, they add together. Since the same current is flowing through each resistance, the total voltage drop is total current times the total resistance. For a split-phase system, the total resistance is equal to two times the one-way resistance. For a three-phase system, each of the three line currents and resistances must be calculated.

NOTICE NEC guidelines for voltage drop on feeder and branch circuit conductors will not be sufficient for microinverter branch circuits that contain the maximum allowable microinverters. This is due to high inherent voltage rise on the branch circuit.

For more information, refer to the *Voltage Drop Calculations* Application Note at http://www.enphase.com/support/downloads.

b. Install an outdoor rated, weather-proof junction box at a suitable location on the PV racking system (typically at the end of a row of modules).

c. Provide an AC connection from the junction box back to the utility interconnection, using equipment and practice as required by the NEC and local jurisdictions.

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Step 3 – Position the Enphase Engage Cable

NOTICE

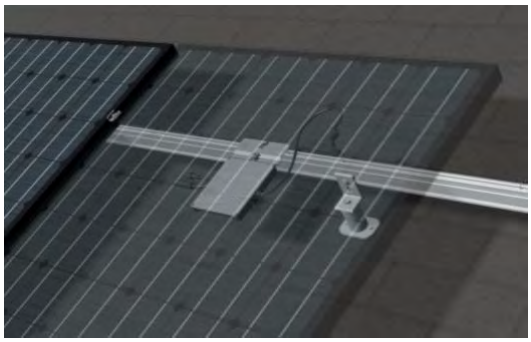
Many modules have a central stiffening brace. In these cases, do **not** position the connector and microinverter at the exact center of the PV module, but position the cable so that connectors do not conflict with the braces.

a. Lay the cabling along the route it will travel, positioning the connectors so that they align with the PV modules.

b. Module widths vary by manufacturer. On the Engage Cable, connectors are spaced at intervals to allow for the widest PV modules compatible with Enphase Microinverters. If narrower modules are used, it may be necessary to account for excess cable by adding a loop of cable at suitable intervals.

Step 4 – Attach the Microinverters to the Racking

a. **Mount the microinverters according to the microinverter manual.** Ensure both that the microinverter does not interfere with the PV module frames or stiffening brace, and that the drop cable from the microinverter can easily reach the connector on the cable.



b. Ground the microinverters using either a continuous, unbroken grounding conductor or approved grounding washers. Follow the methods described in the *M215 Installation and Operation Manual* at http://www.enphase.com/support/downloads.

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Step 5 – Dress the Engage Cable

NOTICE **Adhere to the following requirements:**

- Do not expose the connection to directed, pressurized liquid (water jets, etc.).
- Do not expose the connection to continuous immersion.
- Do not expose the AC connector to continuous tension (e.g., tension due to pulling or bending the cable near the connection)
- Use only the connectors and cables provided.
- Do not allow contamination or debris in the connectors.
- Use the cable and connectors only when all parts are present and intact.
- Fit the connection using only the prescribed tools.
- There are two release holes in the cable connector. These holes are used to disconnect the connector. **Keep these release holes clear and accessible.**

a. Attach the Engage Cable to the rack using the included clips, or you may use tie wraps. The cable clips are designed so that the drop cable from the microinverter can also be dressed into the clip underneath the cable.

b. Dress any excess cabling in loops so that cabling does not contact the roof.

⚠WARNING **Tripping Hazard**. Do **not** leave the cabling to rest on the roof. Loose cables might become a tripping hazard. Attach the power cables correctly.

c. Place tie wraps or clips on either side of the drop connector. Use one or two additional clips, tie wraps, or other support scheme to secure the cable between connectors.

d. Remove the temporary shipping cap from the Engage Cable.

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Step 5 – Dress the Engage Cable (continued)

e. Connect the microinverter and listen for two clicks as the two prongs engage. Ensure that **both** latching mechanisms have engaged.

NOTICE

The connector has not been designed for repeated linking and unlinking.

f. Repeat steps **a** through **e** for all microinverters in the branch.

g. Cover any unused connector with a watertight sealing cap. Listen for two clicks as the connectors engage. Ensure that **both** latching mechanisms have engaged.

NOTICE

Make sure watertight sealing caps are installed on **all** unused AC connectors. Unused AC connectors are live when the system is energized by the utility.

NOTICE

Do not use the shipping cap to cover unused connectors. The shipping cap does not provide an adequate environmental seal. Enphase watertight sealing caps (included in the Installation Kit) are required for protection against moisture ingress.

NOTICE

Enphase watertight sealing caps are IP67 rated. Within the term "IP67", "IP" indicates an Ingress Protection (IP) rating against dust and liquids. This specific rating of IP67 indicates that this connector protects against all dust particles and immersion in liquid.

NOTICE

If you need to remove a watertight sealing cap, you must use the Enphase disconnect tool or a #2 Phillips screwdriver.

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Step 6 – Terminate the Unused End of the Engage Cable

Attaching the Terminator

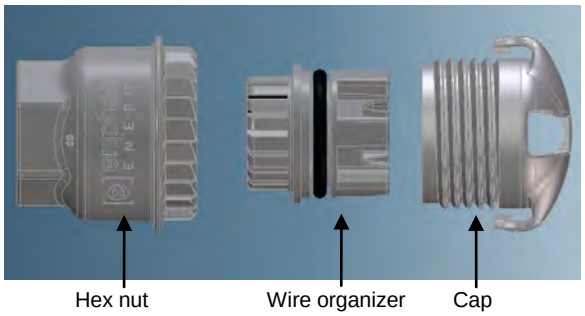
NOTICE The terminator is intended for one-time use only. If you open the terminator following installation, the latching mechanism is destroyed and the terminator cap cannot be used again. If the latching mechanism is defective, the terminator must not be used. The latching mechanism must not be circumvented or manipulated.

NOTICE **Adhere to the following requirements:**

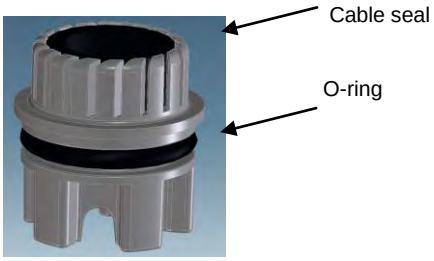
- Use of the terminator assembly is the only method allowed to seal the conductor end of the trunk.
- Do not expose the terminator cap to directed, pressurized liquid (water jets, etc.).
- Do not expose the terminator cap to continuous immersion.
- Do not expose the terminator cap to continuous tension (e.g., tension due to pulling or bending the cable near the terminator cap)
- Do not install or use in potentially explosive environments.
- Do not allow the terminator to come into contact with open flame.
- Use the terminator cap assembly only when all parts are present and intact.
- Fit the terminator cap using only the prescribed tools.

To attach the terminator:

a. Check the terminator cap assembly for completeness. It is made up of the individual parts shown.



b. To guarantee the safety of the wire organizer and to ensure that it remains sealed, please make sure that all parts are present and that all seals are seated correctly in the wire organizer.



The wire organizer must be complete, as shown.

DANGER **Risk of Electrical Shock.** The terminator cap must not be installed while power is connected.

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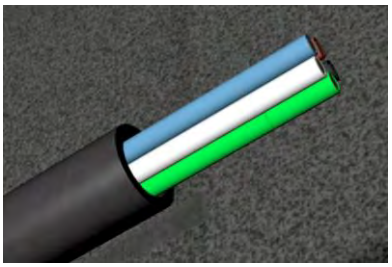
c. Strip at least 60 mm (2.5 inches) of the shielding from the conductors.

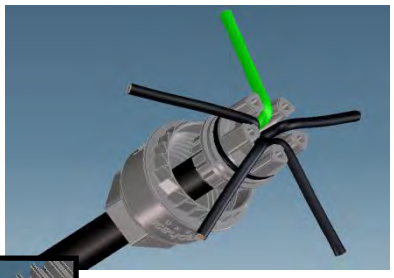


NOTICE If the exposed wires are damaged, system function can no longer be guaranteed.

d. Slide the hex nut onto the cable.

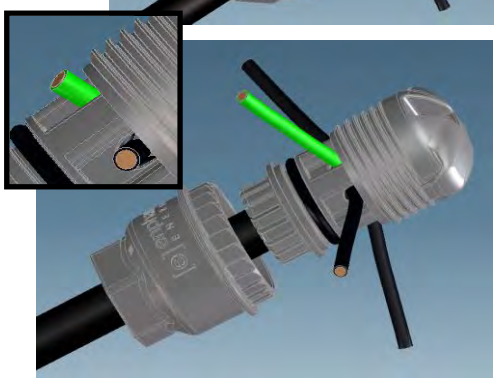
e. Insert the cable all the way into the wire organizer (up to the stop).

f. Bend the individual wires into the slots (spaces) on the wire organizer.



g. Using a diagonal cutter, trim wires to the correct length so that they fit cleanly into the slots (spaces) in the wire organizer.

h. Press the cap onto the wire organizer, bending the wires into the slots of the wire organizer.



If the wires resist being pressed into the cap, you may need to trim the wires a little further using a diagonal cutter.

i. Screw the hex nut onto the cap.

NOTICE Never unscrew the hex nut as this can twist and damage the cable.

j. Insert a #2 Philips screwdriver into the slot on the cap to hold it in place. (Alternatively you can hold the cap firmly in place using the Enphase hand tool).

k. Use a 24mm (7/8 inch) wrench and tighten the nut until the latching mechanism has been screwed all the way to the base.

l. Use a tie wrap or cable clip to attach the cable to the racking, so that the cable and terminator do not touch the roof.

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Replacing or Removing the Terminator

If the terminator must be replaced or removed, observe the following.

DANGER **Risk of Electrical Shock.** Never open, remove or replace the terminator while it is connected to the power supply.

NOTICE Damage to the latching mechanism **cannot** be seen with the naked eye. Label the opened terminator and dispose of it immediately to ensure that it cannot be reused accidentally.

NOTICE The terminator is intended for **one-time use only**. If you open the terminator again following the installation, this will destroy the latching mechanism, meaning that the unit then **cannot** be used again.

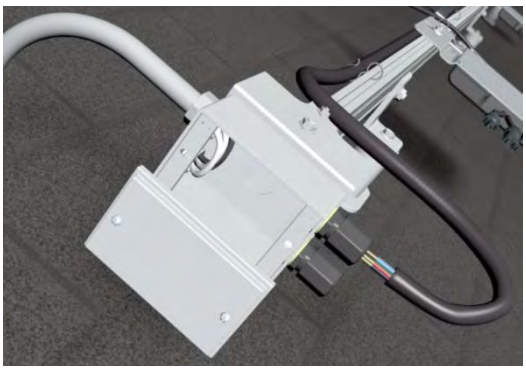
a. Remove the terminator by cutting it off using a diagonal cutter set flush against the end of the cable.

b. Replace the terminator as described in the previous steps, beginning on page 17.

Step 7 – Connect the Engage Cable to Junction Box(es)

NOTICE Perform the following steps in accordance with NEC regulations.

a. Connect Engage Cable into the AC branch circuit junction box using an appropriate gland or strain relief fitting. The cable requires a strain relief connector with an opening of 1.3 cm (0.5 inches) in diameter.



b. Connect the Engage Cable into additional junction boxes as needed to transition to conduit between smaller sub-arrays. Remember to adhere to branch limits for the microinverters being used.

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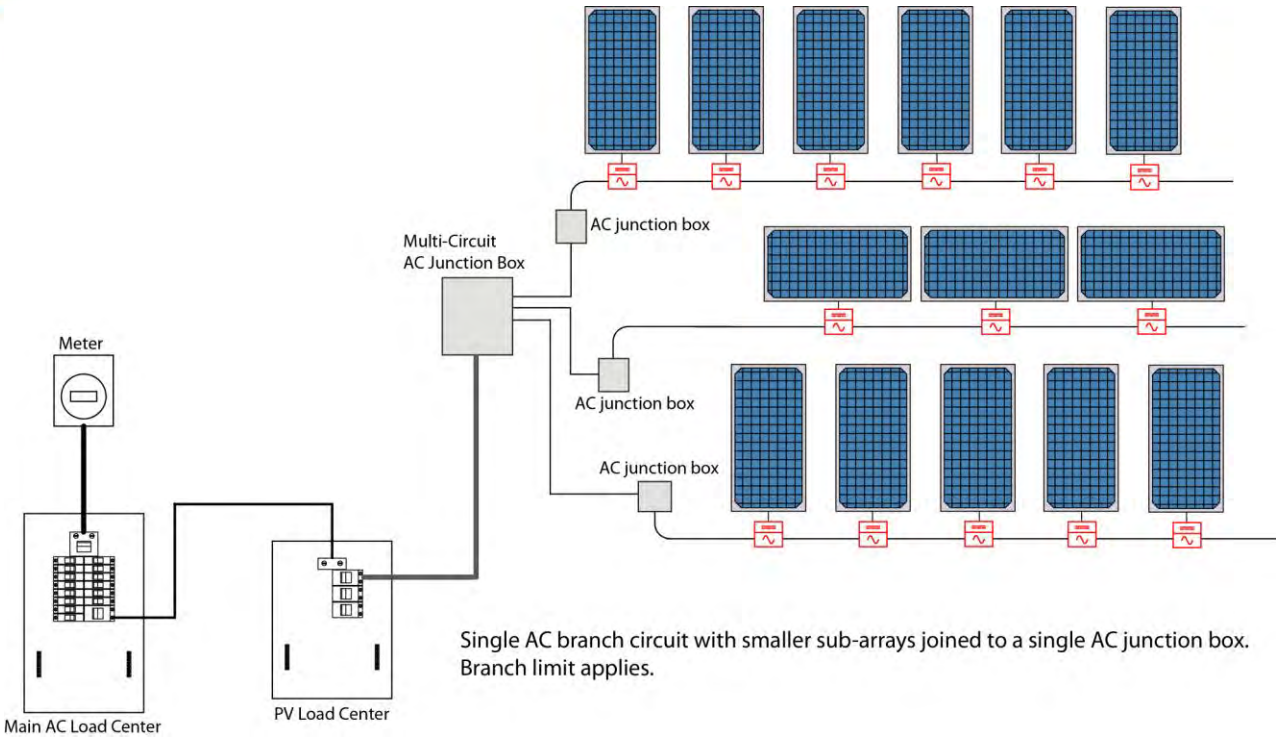

Single AC branch circuit with smaller sub-arrays joined to a single AC junction box. Branch limit applies.

Refer to the wiring diagrams located in the Appendix of this manual for more information.

NOTICE The Engage Cable uses a different wiring scheme than used with other Enphase Microinverters. Be aware of the difference in wire color code.

The 12 AWG conductors are identified as follows: L1 is sheathed in Black, L2 is sheathed in red, L3 is sheathed in blue (208 Vac only), Neutral is sheathed in white, and Ground is sheathed in green. The grounding wire is used to ground the microinverters. A WEEB or continuous ground is required in addition to this green grounding wire.

Balanced 208 VAC is accomplished by alternating phases between microinverters.

240 Volt AC Split Phase Wiring	208 Volt AC Three-Phase Wiring
Black – L1 Red – L2 White – Neutral Green - Ground	Black – L1 Red – L2 Blue – L3 White – Neutral Green - Ground

The green wire acts as equipment ground. A continuous GEC for system ground is also required as described in the next step.

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Step 8 – Verification and Commissioning

NOTICE **Prior to final connection to the utility grid, ensure that all AC and DC wiring is correct.**

a. Ensure that none of the AC and DC wires are pinched or damaged.

b. Ensure that all junction boxes are properly closed.

c. Ensure that all unused connectors are capped.

d. Ensure that all connectors are properly seated.

e. Install the microinverters and commission the system as instructed by the Enphase Microinverter installation and operation manual.

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Disconnecting a Microinverter from the Engage Cable

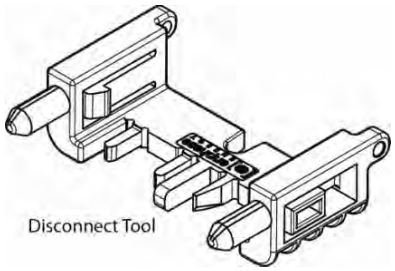
To ensure the microinverter is not disconnected from the PV modules under load, adhere to the following disconnection steps in the order shown:

1. Disconnect the microinverter AC connector from the Engage Cable.
2. Cover the module with an opaque cover.
3. Using a DC current probe, verify there is no current flowing in the DC wires between the PV module and the microinverter.

NOTICE

Care should be taken when measuring DC currents due to the fact that most clamp-on meters must be zeroed first and tend to drift with time.

4. Disconnect the PV module DC wire connectors from the microinverter.
5. Remove the microinverter from the PV array racking.
6. The microinverter connectors are tool-removable only. The installation kit includes a disconnect tool with two prongs. To disconnect a microinverter from the cabling system, insert these two prongs into the two holes in the cable connector. Squeeze the sides of the disconnect tool to engage with the connector. Rock the connector back and forth while pulling gently to disengage.



7. If the disconnect tool is not available, a #2 Phillips screwdriver can be used in its place. Insert the screwdriver into one hole, rock that side of the drop connector out, then insert the screwdriver into the other hole and pull the connector out entirely.

⚠ DANGER

Risk of Electrical Shock. Do not leave the drop connector uncovered for an extended period. If you do not plan to replace the microinverter immediately, you must cover any unused connector with a watertight sealing cap. Listen for two clicks as the connectors engage.

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Technical Data

Specification	Value
System temperature range (ambient)	-40C to +65C (-40F to 149F)
Cable temperature rating	90C Dry / 90C Wet
Cable insulator rating	THWN-2
Environmental protection rating	IEC 60529 IP67
UV exposure rating	UL 746 C, F1
Conductor gauge	12AWG
Maximum current carrying capacity of the Engage Cable	20 amperes
Maximum current carrying capacity of the drop cable (on the microinverter)	4 amperes
Cable bundle diameter	1.3 cm (0.525″)
Drop connector dimensions	11.8 cm x 6.0 cm x 3.2 cm (4.64″ x 2.36″ x 1.25″)
Terminator cap dimensions	3.6 cm diameter x 5.1 cm tall (1.4″ x 2″)
Cable weights [about 1lb (0.5 kg) per drop]: 30-drop cable 40-drop cable 240-drop cable	 30 lbs/14 kg (approximate) 40 lbs/18 kg (approximate) 240 lbs/110 kg (approximate)

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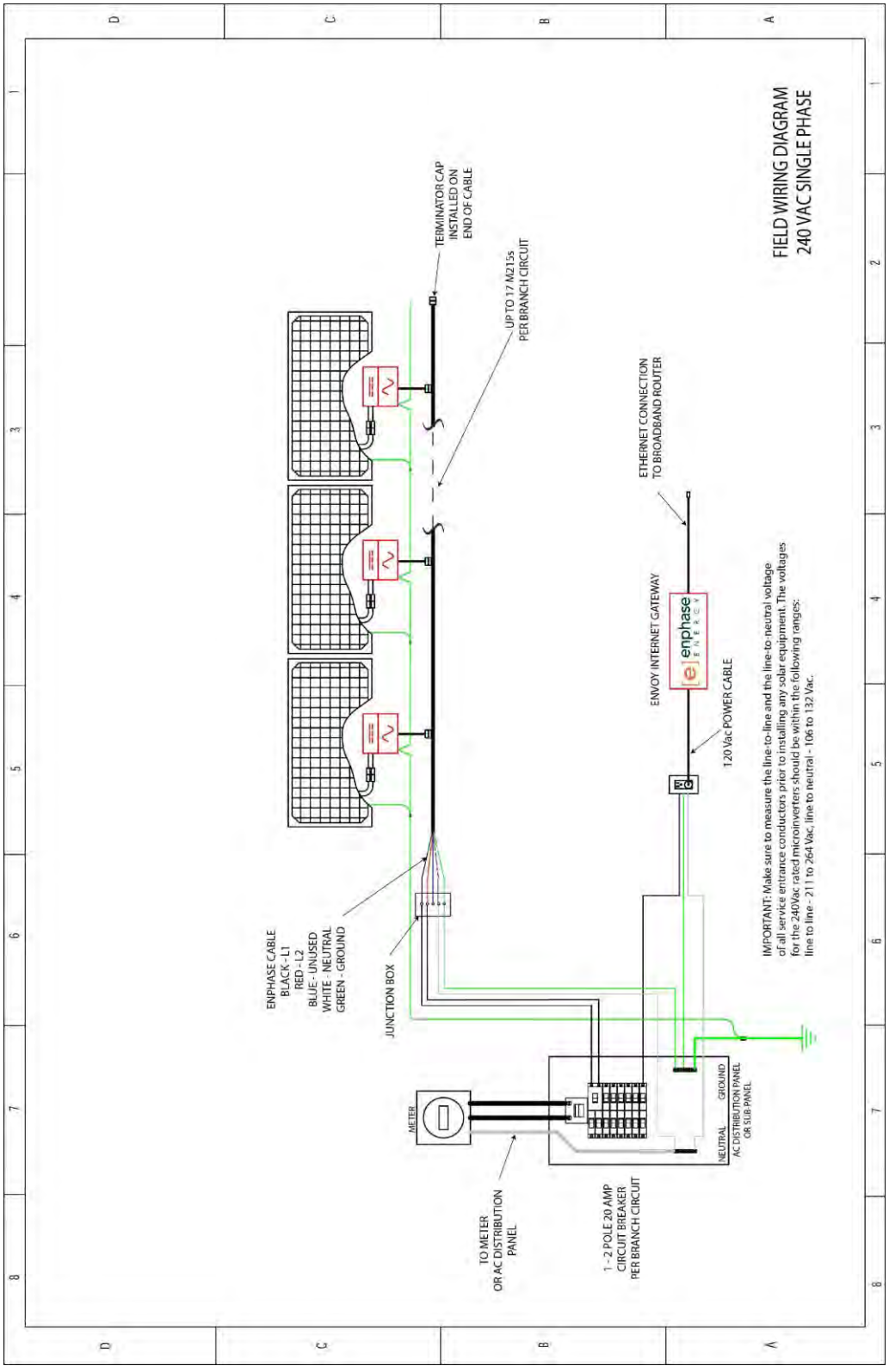
Appendix – Sample Wiring Diagrams

Sample Wiring Diagram – 240 Vac



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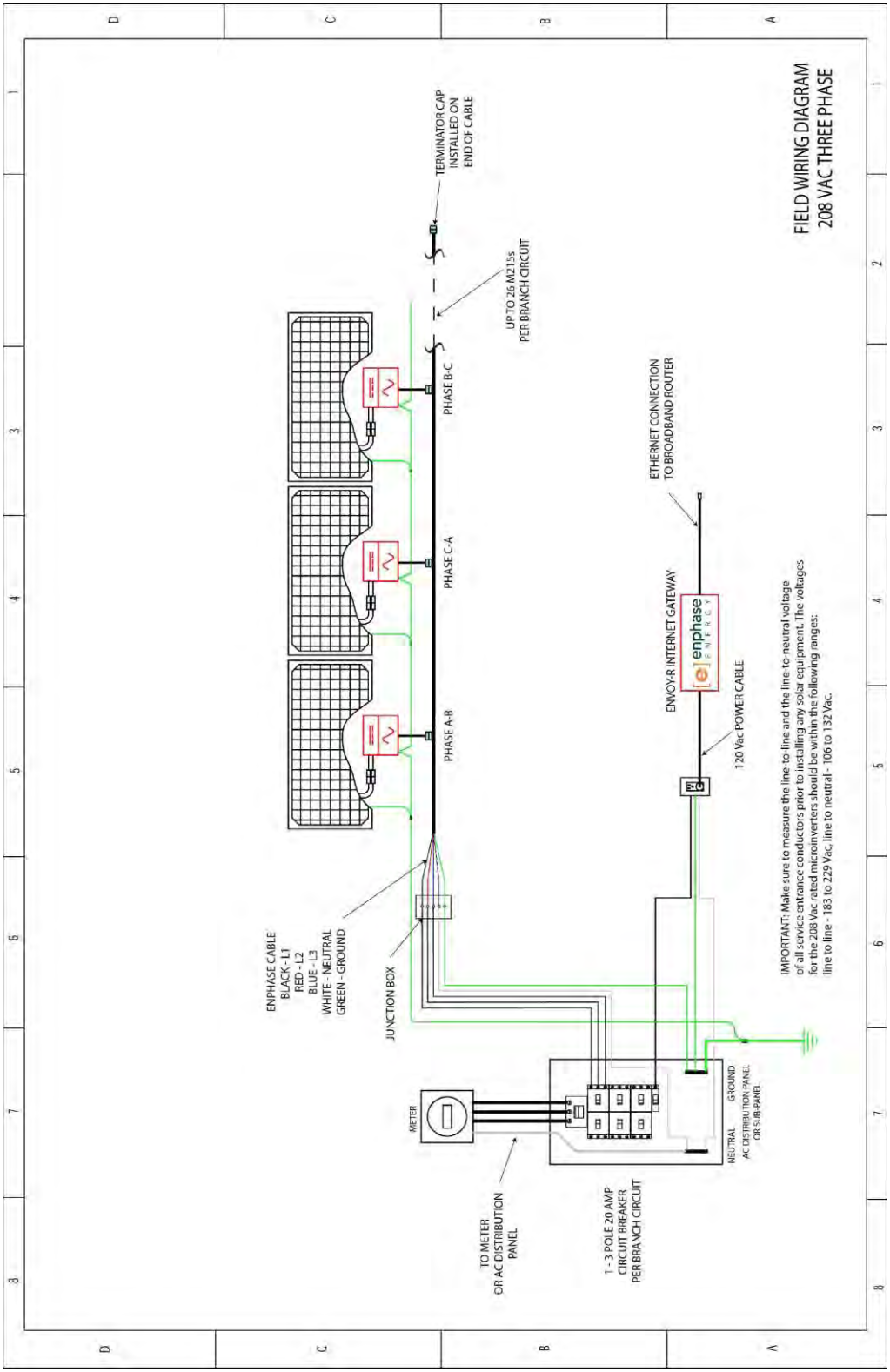
Sample Wiring Diagram – 208 Vac


FIELD WIRING DIAGRAM
208 VAC THREE PHASE
TERMINATOR CAP INSTALLED ON END OF CABLE
UP TO 26 M215s PER BRANCH CIRCUIT
PHASE B-C
PHASE C-A
PHASE A-B
ETHERNET CONNECTION TO BROADBAND ROUTER
ENVOY-R INTERNET GATEWAY
120 Vac POWER CABLE
ENPHASE CABLE
BLACK - L1
RED - L2
BLUE - L3
WHITE - NEUTRAL
GREEN - GROUND
JUNCTION BOX
METER
TO METER OR AC DISTRIBUTION PANEL
1 - 3 POLE 20 AMP CIRCUIT BREAKER PER BRANCH CIRCUIT
NEUTRAL
GROUND
AC DISTRIBUTION PANEL OR SUB-PANEL
IMPORTANT: Make sure to measure the line-to-line and the line-to-neutral voltage of all service entrance conductors prior to installing any solar equipment. The voltages for the 208 Vac rated microinverters should be within the following ranges:
line to line - 183 to 229 Vac, line to neutral - 106 to 132 Vac.

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Enphase Energy Inc.
201 1St Street
Petaluma, CA 94952
Phone: 707-763-4784
TOLL FREE: 877-797-4743
Fax: 707-763-0784
www.enphase.com
info@enphaseenergy.com

Envoy Communications Gateway™

The Enphase **Envoy® Communications Gateway** provides network access to the solar array enabling comprehensive monitoring and management of an Enphase system.

Solar professionals and system owners can easily check the status of their Enphase System using the Envoy's LCD display or get more detailed performance data via Enlighten® Software, included with purchase of Envoy.

SMART

- Includes web-based monitoring and control
- Integrates with smart energy devices
- Automatically upgrades and sends performance data

SIMPLE

- Plug and play installation
- Flexible network configuration
- No additional AC wiring required

SCALABLE

- Residential or commercial ready out of the box
- Supports up to 600 microinverters

enphase® ENERGY

C US

INTERFACE	
Power Line Communications	Enphase proprietary
Local Area Network (LAN)	10/100 auto-sensing, auto-negotiating, 802.3

LAN CONNECTION OPTIONS	
Cable Assembly, Ethernet, RJ45, Orange, 10ft	Included with ENV-120-01 and ENV-120-02
Power line communication bridge pair	Included with ENV-120-01
Wireless N USB adapter (802.11b/g/n)	Included with ENV-120-02

POWER REQUIREMENTS	
AC supply	120 VAC, 60 Hz
Power consumption	2.5 watts typical, 7 watts maximum

CAPACITY	
Number of microinverters polled	Recommended up to 600

MECHANICAL DATA	
Dimensions (WxHxD)	222.5 mm x 112 mm x 43.2 mm (8.8” x 4.4” x 1.7”)
Weight	340 g (12 oz.)
Ambient temperature range	-40ºC to +65ºC (-40º to 149ºF)
Cooling	Natural convection—no fans
Enclosure environmental rating	Indoor NEMA 1

FEATURES	
Standard warranty term	Two years
Compliance	UL 60950-1, EN 60950-1, CSA22.2 No. 60950-1 and IEC 60950-1, FCC Part 15 Class B
API available	System-level production data

To learn more about Enphase Microinverter technology, visit **enphase.com**

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Appendix G – Fall Protection

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FREESTANDING COUNTERWEIGHT ANCHOR

Freestanding Anchor Does Not Require Attachment to Working Surface and Provides a Safe and Versatile Fall Arrest Rated Tie-Off Point!

- Non-penetrating design does not attach to the working surface, reducing the possibility of damage
- Built-in shock absorbing post provides added safety to user and structure
- Fall arrest and restraint rated for one worker for jobsite versatility
- For use in general concrete, steel or asphalt construction
- Approved for use on these roof types: concrete, single ply membrane, bitumen membrane, asphalt sanded and asphalt stone chippings
- Ideal for use on flat surfaces up to a maximum of 5 degrees slope/pitch
- Counterweights are 45 lbs. (20.3kg) and come with a integral carrying handle for easy transport and set-up

FREESTANDING COUNTERWEIGHT ANCHOR

Safe and Secure Anchor The freestanding counterweight anchor provides a tie-off point for personnel performing work on flat roofs or structures. The anchor is fall arrest rated and can be used as a single anchor point system. After set-up, simply attach your shock absorbing lanyard, self retracting lifeline or rope grab and lifeline and you are ready to go.

Non-Penetrating Design This anchor is a counterweight type, simply placed on top of the working surface. Weighted bases are added to rubber trays that are connected to a shock absorbing tie-off post. The anchor's freestanding design installs without penetrating the roof sheathing or surface, saving valuable time and money. In addition, the design reduces the possibility of surface damage, roof leaks and voided roof warranties.

Specialized Load Distributing Design This anchor incorporates a revolutionary shock absorbing system called LEAP™. The LEAP™ post (with tie-off point) has an integral energy absorber that deploys in a controlled manner to absorb the forces generated during a fall. This specialized design provides added safety to the attached worker and better distributes the forces to the anchor and structure. By limiting the forces this way, the integrity of the roof is also preserved.

Easy Installation Installation of the anchor system is simple, fast and efficient. Due to its modular design, the installer will never have to lift more than 45 lbs. (20.3kg). In some applications, the entire system can be lifted (by forklift or crane) into place for instant set-up and use. Refer to instruction manual for complete details.

Counterweight Anchor Models:

7255000: Freestanding Counterweight Anchor, includes sixteen 45 lb. (20.3kg) plates, roof post, base and D-ring

7200439: Single Counterweight Only, 45 lbs. (20.3kg)

Step 1

Align rubber trays into square pattern using notches

Step 2

Install the "L" bolts into the slots on the rubber trays

Step 3

Stack plates (weights) over bolts and onto rubber trays

Step 4

Set post and base onto the "L" bolts and plates

Step 5

Install the remaining four plates and tighten bolts/nuts

Specifications:

Counterweight Plates: Cast iron, galvanized ***Rubber Trays:*** Carbon steel, PVC coating ***"L" Bolts:*** Carbon steel, galvanized
Roof Post and Base: Post is painted stainless steel, the base is painted carbon steel ***D-ring:*** Forged steel, zinc plated
Standards: Meets EN 795:1997 Class E requirements.

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USA: 800.328.6146 • Canada: 800.387.7484 • Asia: +65 6558 7758 • Australia: 1800 245 002 • New Zealand: 0800 212 505
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Form: 9700153 rev: A

New!

MILLER Fusion™

Roof Anchor Post

Permanent or Temporary Solution for Roof Safety

- Versatile single-point anchor adapts to a wide range of roof designs
- Attachment to the roof surface is quick and easy reducing installation time by more than 50%
- Protects the worker by maintaining a secure connection to the structure in the event of a fall
- Protects the structure during a fall with a unique energy-absorbing load distribution system

INNOVATIVE ENERGY-ABSORBING DESIGN

MILLER® by SPERIAN

New!

MILLER Fusion™ Roof Anchor Post

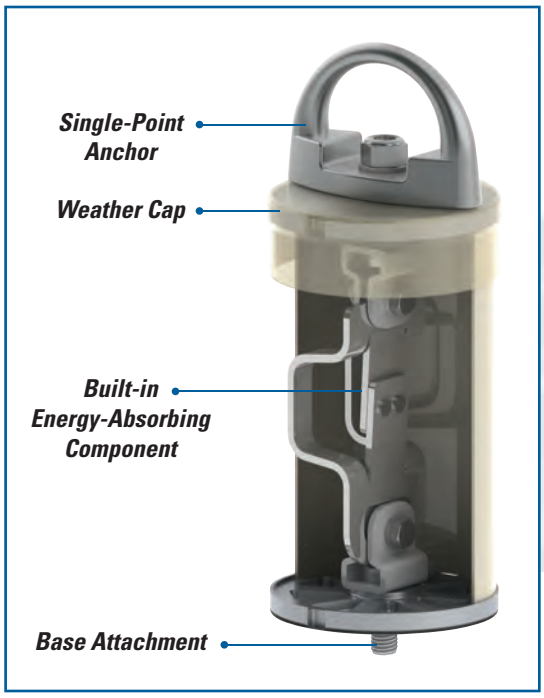
*The new versatile, single-point **Miller Fusion Roof Anchor Post** adapts to a wide range of roof designs with its innovative base plate engineered for temporary or permanent installation to the roof surface.*

When properly installed, a dependable fall protection connection is established. Should a fall occur, forces are reduced with its energy-absorbing design to maintain a secure connection to the structure.

*The easy-to-install **Miller Fusion Roof Anchor Post** is designed for quick set-up and does not require roof penetration to sub-surface rafters or trusses.*

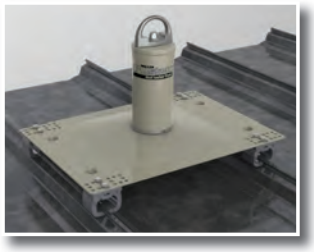
- **Versatile single-point anchor adapts to a variety of roof designs** – With a variety of models available, the Miller Fusion Roof Anchor Post can accommodate most industrial roof designs including standing seam, membrane, built-up, metal sheathing, concrete and wood.
- **Attaches to the surface of existing roof structures** – Quick, easy installation reduces cost requiring minimal labor and eliminating the need for roof penetration and repair.
- **Significantly reduces the fall forces on the roof structure** – In the event of a fall, the top of the Miller Fusion Roof Anchor Post reorients with the force in a direct line and activates the patent-pending energy absorber.
- **Durable design that withstands the changing outdoor environment** – Internal components are constructed of stainless steel. The steel post and base are plated with zinc followed by a premium powder coating for two layers of protection.
- Models for steel decking, concrete and wood can be used on other non-roof structures.

Modular bar extenders accommodate additional standing seam widths.



In the event of a fall, the Miller Fusion Roof Anchor Post orients in the direction of the force, the built-in, energy-absorbing component activates and the base remains securely attached to the roof surface.

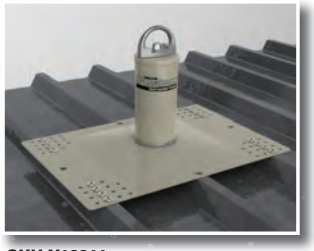
Miller Fusion Roof Anchor Post adapts to a variety of roof structures



SKU X10001

Standing Seam Design

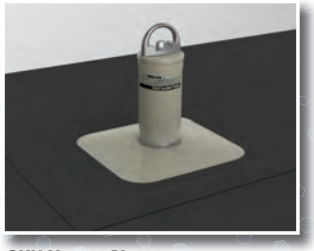
- Aluminum clamping mechanism is designed to pre-install to the base plate and is self centering for easy installation.
- The clamping bolts are tightened from above the plate for easy fastening and inspection.
- Can be used for permanent and temporary installations.
- Three models are available to accommodate standing seam spacing up to 24-inches *(610 mm)*.*



SKU X10011

Metal Sheathing Design

- Designed to attach to metal sheathing with a minimum 24 gauge *(0.024-inch [.61 mm])* thickness.
- Hardware kit includes sealing materials to prevent water damage to roof.



SKU X10030/X10031

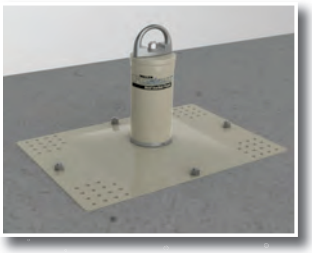
Membrane/Built-up Design

- Easy-to-install toggle kit fastens through membrane, insulation and into metal sheathing, wood sheathing or concrete.
- Models available for built-up roof thicknesses accommodate up to 10.5 inches *(267 mm)*.

SKU X10040

Wood Design

- Includes lag screw kit.
- Installs into plywood with minimum thickness of 5/8-inch *(15.9 mm)* CDX.
- *Designed for temporary installation only.*



SKU X10050

Concrete Decking Design

- Includes concrete expansion anchor kit.
- Installs into concrete decking with minimum thickness of 6.5 inches *(165 mm)* and minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*.

SKU X10020

Multi-Purpose Metal Sheathing, Wood and Concrete Design

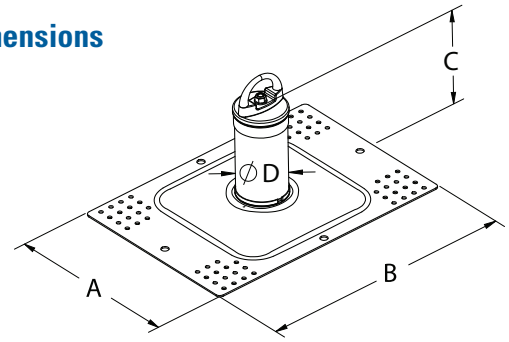
- This multi-purpose post uses the same base as models X10011, X10040 and X10050.
- Miller specified hardware must be purchased for this base. *(This model does not include hardware.)*

Applications

- *Roof inspection and maintenance*
- *Air conditioning, ventilation fan and solar panel maintenance*
- *Skylight cleaning*
- *Debris removal from gutters*
- *Installation and maintenance of satellite dishes and other communication systems*

**Complete list of models (SKUs) on back page.*

Dimensions



SKU	WIDTH A	LENGTH B	HEIGHT C	POST DIA. D
X10000 X10010	15.25 in. *(387 mm)*	18.0 in. *(457 mm)*	8.6 in. *(218 mm)*	4.0 in. *(102 mm)*
X10001 X10011 X10020 X10040 X10050		22.0 in. *(559 mm)*		
X10030 X10031			9.0 in. *(229 mm)*	
X10002	15.6 in. *(396 mm)*	26.0 in. *(660 mm)*	9.56 in. *(243 mm)*	

Specifications

Roof Anchor Post Materials

Energy Absorber:	Stainless Steel
Internal Connecting Components:	Stainless Steel
Top and Bottom Post Plates:	Anodized Cast Aluminum
Standing Seam/Wood/Metal Base Plate:	Two-layer Zinc/Powder-Coated Steel
Post Tube:	Zinc/Powder-Coated Steel
Post/Base Plate Seal:	HDPE
Post Cap:	Vinyl w/UV Inhibitor

Connection Components Materials

Standing Seam Clamps:	Anodized Aluminum/Stainless Steel
Extender Bar for Standing Seams:	Anodized Aluminum/Stainless Steel
Hardware for Metal Sheathing:	Hot Dip Galvanized/Neoprene
Hardware for Membrane:	Zinc-Plated Steel/PVC/Neoprene
Hardware for Wood:	Zinc-Plated Steel
Hardware for Concrete:	Stainless Steel

Performance

Activation Force:	1000 lbs. *(4.4 kN)*
Maximum Capacity:	310 lbs. *(140.6 kg)*

Fusion Roof Anchor Post

SKU	Description	Designed to Accommodate
STANDING SEAM ROOFING – Includes post with base and standing seam clamping assembly kit		
X10000	Small base	Standing seam spacing from 11.75 in. *(298 mm)* to 17 in. *(432 mm)*
X10001	Large base	Standing seam spacing from 11.75 in. *(298 mm)* to 21.25 in. *(540 mm)*
X10002	Large base & extension bars	Standing seam spacing from 11.75 in. *(298 mm)* to 24 in. *(610 mm)*
METAL SHEATHING ROOFING – Includes post with base and rivet kit with sealing washers and mastic tape		
X10010	Small base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])*
X10011	Large base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm]).* Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments.
MEMBRANE/BUILT-UP ROOFING – Includes post with base and toggle bolt kit		
X10030	Up to 5.5 in. *(140 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of up to 5.5 in. *(140 mm)*
X10031	> 5.5 in. *(140 mm)* & up to 10.5 in. *(267 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of > 5.5 in. *(140 mm)* up to 10.5 in. *(267 mm)*
WOOD SHEATHING (TEMPORARY INSTALLATIONS ONLY) – Includes post with base and lag screw kit		
X10040	Wood sheathing	Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX
CONCRETE ROOFING – Includes post with base and concrete expansion bolt anchor kit		
X10050	Concrete	Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*
MULTI-PURPOSE METAL SHEATHING, WOOD AND CONCRETE ROOFING (NO HARDWARE INCLUDED) – Includes post with base. Hardware selection is based on the application. See instruction manual for hardware specifications.		
X10020	Metal sheathing, wood or concrete	• Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])* • Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments. • Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX • Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*

Meets or exceeds all applicable industry standards including OSHA, ANSI A10.32 and Z359.1-2007.

This equipment should only be used after reading the manufacturer's instructions. Failure to follow instructions could result in serious injury or fatality.

MILLER® by SPERIAN

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Fax 800/892-4078 or Fax 814/432-2415

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